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Contents

In This Issue

When editor Daniel Hausman introduced the first issue of *Economics and Philosophy,* he hailed the release of economics from the chains of logical positivism and lauded the renewed awareness by economists of the roots of their theory:

> "The final collapse of logical positivism or logical empiricism, which we might date to the 1960s, has reopened a wide range of philosophical questions about the causes and character of scientific progress. . . . . Serious work in economics often makes controversial methodological claims. Deep disputes in economic theory . . . are frequently disputes as much about how economics should be done as they are about particular results." *(Journal of Econ. and Phil.,* Apr. 1985, pp. 1, 3)

In this issue, the invited essay by Castle recalls to agricultural economics some of the important methodological issues such as verification and explanation that have occupied the attention of theory economists for the past two decades. He mentions, for example, the treatment of anomalies, or contrary findings, in empirical research. Anomalies have now risen to the stature of a separate section in one of the journals published by the American Economic Association.

One of Castle's important messages relates to the personal benefit and collective cost of specialization. He is concerned that the rigors of orthodoxy, particularly in graduate school, require elimination of methodological diversity. Single theoretical formulations are repeated, and individual researchers become hardened against challenges to adopted theories and philosophical foundations. He prescribes pluralism in theory and method. There is much more in his essay and we invite comment and responses.

Davison, Arnade, and Hallahan compare three approaches to estimating elasticities in major soybean export markets. Their concern is not only the limited number of estimates of longrun elasticities of demand for soybeans, but the inadequacy of much agricultural trade modeling for forecasting. Their linear, log-linear, and Box-Cox models do present some anomalies compared with the naive (last year) model, but they demonstrate, nonetheless, that functional form makes a difference. Income and price elasticities range widely from elastic to inelastic in the seven markets in the study.

Heimlich argues that if highly erodible land is not less productive, hence of lower value, then the costs of removing the erodible land from production by traditional government programs will cost more than is generally assumed. With data from the National Resources Inventory, field crop yields, and crop budgets, he tested differences in revenue from erodible and non-erodible land. The differences are weak, so he concludes that blanket policies that rely on erodible land's low productivity are misplaced.

Babula and Bessler model the responsiveness of the market to a shock, the effect of drought on wheat prices and wheat-based goods at the processor and consumer levels. Their vector autoregression model showed swift upward response in processor prices and slower, enduring effects on consumer prices.

Books on a wide variety of subjects are reviewed in this issue beginning with Szmedra's critique of Antle's book on production risk applied to pesticide policy. The favorable evaluation, particularly of the guides to empirical testing, is summed by the reviewer's "an enjoyable read." Likewise, Denbaly compliments Paarlberg and Chambers for producing a unique contribution to the relatively new field of macroeconomy and agriculture.

Coyle reviews Hayami, who recommends strong medicine, mostly based on market principles, for the inefficient and trade-protected Japanese farmer. Coyle commends the analysis and conclusion that structural reform is needed to improve the efficiency of Japanese agriculture. Bajwa reviews the book edited by O'Mara on supplementary irrigation. O'Mara's book includes references to irrigation development models in California, the Indus Basin, and north China.

The book on food subsidies in developing countries edited by Pinstrup-Andersen is less than completely useful to readers in developing countries, according to reviewer Yetley. Even so, says Yetley, the book is one of the few available on the subject and is a helpful source of references. Hyde remarks on the renewal of interest in land tenure as a research topic in agriculture and resource economics and points to the book on Thailand by Feder and others as an example of how such research should be done. He endorses the book's emphasis on secure tenure for efficiency and

long-term investment. Shane calls the OECD book on national policies and agricultural trade a benchmark study in dealing with the problems of world trade interdependence and conflicting domestic policies. While generally supportive of the study, Shane notes its limited commodity and country coverage, partial equilibrium, static analysis, and narrowness of the liberalization scenario.

A final note on research specialization. I hear complaints about the technical specialization of articles in this journal and others. Specialization in JAER is not surprising because this is the house journal of an agency of research specialists. All the incentives to specialize mentioned by Castle reside here as well as in academia. Our submissions, hence acceptances and published articles, reflect work in process and only rarely do we share in the whole picture of a researcher's or research unit's undertaking. The solution rests with individuals willing to extend beyond their specialty, to join others and supply those integrative overviews we love to read but fear to write.

Gene Wunderlich

Economic Theory in Agricultural Economics Research

Emery N. Castle

An inevitable tension prevails between the application of a science and its parent discipline. The worker who wishes to address actual problems must use a general theory that is often ambiguous when applied in certain circumstances. Few contemporary agricultural economists would deny the importance of economic theory, but opinions vary about its use generally and the most effective specific theory for addressing particular problems.

Agricultural economists use as well as contribute to economic theory. A few examples of theory contributions serve to make this point.

T.W. Schultz and J. Kenneth Galbraith are agricultural economists whose work is of such generality that they have been claimed by the parent discipline of economics. Both have held professorships in recognized university departments of economics, and both have served as president of the American Economic Association. Schultz is a Nobel Laureate in economics. Others, Fred Waugh, Mordecai Ezekiel, and Elmer Working, for example, have done research that was promptly recognized in the parent discipline and became a part of mainstream literature. Marion Clawson's theoretical insight on demand for outdoor recreation led to an enormous literature in recreation economics. Original work by other agricultural economists was recognized only after comparable discoveries had been made by economists. The work by Heady and Dillon preceded by a decade comparable developments on duality in economics (Berndt and Field, p. 3).[1] Halter, Carter, and Hocking's note on the transcendental production function anticipated the "translog" production function in current use. Mark Regan's contribution in using welfare economics as a theoretical base for benefit-cost analysis was recognized by only a few contemporaries doing comparable work. In Regan's case, it probably could not have been otherwise because of the nature of his USDA appointment. As a member of the interagency committee that developed the controversial "Greenbook," he was not free to publish his work independently until considerable time had passed. By then others had covered the same ground in more academically oriented literature.

Castle is professor and chair of the University Graduate Faculty of Economics at Oregon State University, Corvallis. I thank the following people who advised me on this essay: Richard Adams, Olvar Bergland, Steven Buccola, Clark Edwards, Richard Johnston, Bruce Rettig, Bruce Weber, and Gene Wunderlich.

[1]See complete citation at end of article.

Intensity of Use of Economic Theory

Agricultural economic literature varies with respect to the intensity of use of economic theory. At one extreme, theory is used only as a general guide to inquiry by assisting in delineating problems, isolating major variables, and suggesting cause and effect relationships. Empirical investigations resulting from such an approach may be, but are not necessarily, highly quantitative. Here, one's primary intent is not to question the applicability of economic theory, but inadequacies or anomalies may be noted and preserved in the hope they will be addressed in subsequent theoretical investigations. This general use of theory does not permit theory to be "tested" except in a most indirect way.

The above approach is not in style today. A closer correspondence between theory and real world conditions is now believed more appropriate. This view, which stems from logical positivism, holds that theoretical concepts are valid only if they can be quantified or lead to theoretical propositions that can be quantified. For applied research purposes, theoretical concepts without major modification may be adequate for real world situations (in effect, theoretical propositions are assumed to have empirical content). In such circumstances, the purpose of the investigation is not to question deductions from theory but rather to apply or illustrate them in a particular setting. Rigorous methods may well be employed. Economic models may be specified mathematically, elaborate surveys may be conducted, and sophisticated quantitative techniques may be used. But the employment of such methods will not ensure that either the empirical content of economic theory will be questioned or economic phenomena will be better understood. Theory may be rescued from reality in several ways: models may be reformulated, variables defined differently, significance levels adjusted, and different data sets tried.

The most intensive use of economic theory in applied research assesses the correspondence of theoretical explanations or predictions with reality. An attempt is made to judge whether the investigation has led to an improvement in real world understanding beyond that implicit in the theory. And here is the rub. How is this to be decided, or how does one know that better understanding has been achieved? Neither the philosophy of science nor the methodology of economics provides a ready answer.

Research Methodology in Applied Economics

Logical positivism and logical empiricism dominated the philosophy of science for a period and have had a major influence on the methodology of many disciplines, including economics. Under logical positivism, theoretical propositions are to be tested or confirmed by experience. Many scientific advances have emerged from the research of those who used, or believed they were using, this approach, but there has been a steady erosion in the adherents of this point of view within the philosophy of science. Karl Popper proposed that positivism be modified by requiring that theoretical propositions were scientific only when capable of being falsified. Thomas Kuhn reacted to Popper by saying falsification is not the way science is practiced and questioned whether science could be practiced that way. Others, for example, Peter Feyerabend, have argued against a general methodology in science altogether. A more moderate position is that of Imre Lakatos, who believes science proceeds in the context of research programs, rather than by crucial tests of particular hypotheses. He sets forth criteria for judging if research programs are progressive or degenerative (see Blaug; Caldwell; and Hausman for summaries).

These developments in the philosophy of science have not gone unnoticed in economics. A journal, *Economics and Philosophy,* established in 1985, examines methodological approaches in economics by the use of philosophy as well as economics. Recent books on methodology in economics include Blaug; Caldwell; and McCloskey. Although the three agree on one point (that economists give far more lip service to falsification than can be justified by the use they make of it), their prescriptions for the improvement of economics are quite diverse. Blaug would have economists give greater attention to falsification—they should practice what they preach. Caldwell recommends pluralism: alternative approaches for the explanation of economic phenomena should be pursued and compared. McCloskey is more critical of the rhetoric of economics than of its content. He argues that economists should be more explicit about their methodology. If they were, he believes they would utter fewer brave words about falsification and rigorous tests of theoretical propositions.

Such matters have received some recent attention by agricultural economists. In 1985, Alan Randall organized a session and presented a major paper at the annual meeting of the American Agricultural Economics Association on alternative theoretical approaches utilized in natural resource economics. Yet, one can hardly say that agricultural economists are preoccupied currently with the philosophical or methodological base from which they work. This contrasts with their considerable familiarity with quantitative methods, including operations research techniques and data processing.

Theory and Reality

A theory may be said to be rich in empirical content if it predicts or explains real world phenomena well. The applied economist may assume a theory and use it for a particular purpose rather than test it. For example, the estimation of welfare gains and losses from a particular market intervention is likely to carry with it many theoretical assumptions, some explicit and some implicit, about the way the world actually is.

Few practicing economists would argue, however, that available theories are adequate for all purposes; the applied economist has a major stake in history improvement. Such improvement can occur in at least two ways. One is by a deductive process: making a theory internally consistent with as few premises as possible, given the objectives of the theory. The other is to enrich its capacity to predict or explain (improve its empirical content). Applied economists may be able to make significant contributions in this respect because they typically work with information based on real world experience. Developments in the philosophy of science and the methodology of economics in the past two decades suggest that it would be fruitful for agricultural economists to establish a dialogue on how the empirical content of the theory they use might be improved. Agricultural economists make numerous conjectures, projections, and predictions about events yet to occur. In even greater abundance are explanations of past events, which range from the qualitative to the highly quantitative. But neither set of activities, standing alone, is likely to have much impact on the empirical content of a theory.

The two should be combined. When projections, predictions, or conjectures are made, the raw material for an additional investigation is at hand. For example, when the supply response of a type of farming area is projected, the projection can become a hypothesis for subsequent research. If the projection missed what actually happened, why did the projection err? Were input prices incorrectly specified? Were the coefficients close to what prevailed? Were the behavioral assumptions highly suspect? Conversely, historical explanation of past events can be used to make predictions for comparable future conditions. The announcement of new policy initiatives often creates a laboratory for judging the reliability of explanations of past comparable events.

If this kind of rigorous exposure of theory to reality is to occur, agricultural economists will need to establish an attitude with respect to anomalies or failures of their theories to explain or predict. On Bayesian grounds, it might be argued that existing theory incorporates past discoveries, and that failure of a theory in a particular case pits this past accumulation of knowledge against a single discrepancy. Under such circumstances, the discrepancy may be treated as an anomaly and dismissed. But, if all anomalies are dismissed, the so-called accumulation of knowledge clearly is biased because only confirmations are taken into account. The attitude of the profession regarding the accumulation of discrepancies or anomalies becomes fundamental. Will they be accumulated systematically and conscientiously, or will they be dismissed or ignored? My colleague, Steven T. Buccola, has likened a body of theory to an open access resource. If the incentive system facing applied workers or theory users is inappropriate, the body of theory may be depleted rather than enhanced. If incentives are biased to favor the publication or preservation of theory successes only, a biased view of a theory will develop over time. If failures as well as successes are noted, there is hope a theory will become more robust or that alternative theoretical explanations will be advanced.

On occasion the awards program of the American Agricultural Economics Association has seen fit to recognize research that reported anomalous results. For one example see the award winning publication by Edwards and others. Journals serving agricultural economics should establish explicit policies with respect to the publication of anomalies or theory failures.

Alternative Theories

The prevailing theoretical orthodoxy in agricultural economics is that of neoclassical equilibrium economics. The recent publication of *The New Palgrave: A Dictionary of Economics,* however, calls our attention to the enormous range and diversity in theoretical formulations upon which the agricultural economist may draw. A contemporary classification system would include neoclassical economics, institutional economics, radical or Marxian economics, and Austrian economics (Caldwell and Randall). Surely the adoption of such a classification system is to paint with a broad brush. Not only are there theory subsets within these broad classifications, but concepts from one approach may be utilized within an alternative framework. While overlap among alternative theories may exist, direct comparison of theories is exceedingly difficult. The philosophy of inquiry underlying different theories may not be the same, and it may be inappropriate to apply the same standards to all (Caldwell, chap. 13).

Except for the advantages of specialization, there is no fundamental reason agricultural economists should confine themselves to one theoretical formulation or approach. The benefits of individual specialization are considerable, however, and the costs of pluralism may be high. To learn rigorously the prevailing orthodoxy requires demanding intellectual effort. When a graduate student has done so, there may be insufficient time in a graduate program to acquire an understanding of alternative theories. The result may be research that repeatedly uses a particular theoretical formulation. The mechanical use of the same theoretical formulation may be combined with sophisticated empirical procedures with no provision for the identification, preservation, and subsequent investigation of anomalies or discrepancies. This may create the impression of an advanced scientific enterprise even when there is no accommodation for knowledge growth.

Greater eclecticism in the use of economic theory would improve agricultural economic research (Hausman). This does not necessarily imply the rejection of neoclassical economics. This body of thought has been able to survive because it is capable of alternative interpretations. When a particular formulation of the neoclassical model fails to explain, predict, or give a desired result, it can often be rescued by another plausible neoclassical formulation. For an example, note the great variation in recommendations for a rate of discount on public works projects, many of which have been derived from alternative neoclassical models (Lind). One may note the different policy implications of alternative neoclassical models applied to regional development (Weber and Deaton).

No tract on the use of economic theory for applied research would be complete without mention of the normative base of economics. Economists need not be wedded to a particular normative position such as utilitarianism. Greater flexibility in this respect may make the results of economic analysis more acceptable to noneconomists, a matter of some importance to those numerous agricultural economists who do research designed to evaluate public policies.

Much public policy research in agricultural economics is based on Pareto optimality models or Kaldor-Hicks compensation tests. The appeal of these approaches is that they appear to avoid the necessity of making interpersonal utility comparisons, but Pareto superiority tests provide no guide as to which parties will reap the surplus that results from moving from an "inefficient" to an "efficient" arrangement. Furthermore, the distribution of income and wealth is not usually a variable when such analyses are made. Respectable alternative approaches include the use of social welfare functions as well as "rights"-based

frameworks. The works of the philosophers Rawls and Nozick provide examples of alternative approaches.[2]

According to Rawls, the fundamental rules in society should be derived from behind a veil of ignorance. While Rawls was not the first to use the veil of ignorance technique, it is his formulation that is receiving the greatest attention. Rules may be said to be "fair" if they are formulated by people who have no knowledge of their particular circumstances with respect to such matters as conditions of birth, nationality, race, or generation. By use of this technique, Rawls comes to the conclusions that reorganizations are fair only if those in the least advantageous position benefit from the reorganization. This is not the place to argue the merits of the Rawls position but rather to establish it as an alternative to Pareto-based rules (see Baumol; Varian; and Wunderlich for examples of economic research on fairness).

Nozick's work is at the opposite philosophical pole. He believes individuals have rights and any infringement of those rights is morally unacceptable. According to Nozick, the minimal and maximal state that can be justified is that state which protects people's property rights. As a consequence, people may not be indifferent as to whether goods are produced by the public or private sector, as would be the case for the utilitarian. In the jargon of the welfare economist, rights are in the nature of nonwelfare information. Such information may be incorporated in social welfare functional forms, in function parameters, or as side constraints. Clearly, the imposition on an economic system of this kind of nonwelfare information will have a major impact on outcomes, as would the requirement that "fairness" conditions be met.[3]

Summary and Conclusions

I make a plea for the systematic treatment of anomalies in research and for pluralism in the use of economic theory. Every agricultural economist, of course, is unlikely to become knowledgeable in all facets of economic theory. Nevertheless, a case can be made for greater diversity of theoretical approaches. This applies to alternative uses of neoclassical economics as well as to the employment of concepts from Marxian, Austrian, and institutional economics.

Much of the current policy research done by agricultural economists is greatly influenced by Pareto-based criteria for comparing alternative policy outcomes. Research results stemming from this normative base may not always be persuasive. Users of such research may be unwilling to accept the implicit Pareto version of fairness, or they may not be indifferent with respect to the role of the state. The issue here is not that of selecting the "correct" normative stance but rather of recognizing that alternative normative positions exist and are capable of being incorporated into economic research.

[2]The final part of this essay has benefited greatly from conversations with Steven Buccola.

[3]Nozick's position does not exhaust the possibilities of the rights-based approach. Welfare state entitlement to certain necessities might also be viewed as a right imposed on an economic system.

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Box-Cox Estimation of U.S. Soybean Exports

Cecil W. Davison, Carlos A. Arnade, and Charles B. Hallahan

Abstract. *U.S. soybean exports to seven major markets are estimated with linear, log-linear, and Box-Cox specifications. Estimates from the three approaches are compared to address these issues regarding the agricultural trade literature: functional form selection, longrun price elasticity estimates, and validation of models beyond the sample data. Functional form appreciably affected forecasts outside the sample and the price and income elasticity estimates, which range from elastic to inelastic across markets. This multiple-market approach provides information that could help policymakers and exporters tailor export marketing strategies to fit specific markets.*

Keywords. *Soybean exports, price elasticities, income elasticities, Box-Cox estimation.*

Elasticity estimates from foreign country import demand equations are important to U.S. policymakers and exporters who want to expand U.S. agricultural exports and increase export revenues. However, elasticity estimates in the agricultural trade literature, especially those from U.S. and rest-of-the-world models, have little consensus on meaningful sizes for own- and cross-price elasticities for individual commodity exports (*12*, p. 36; *25*, p. 5).[1] Thompson said "Two econometric problems pervade much of the empirical work that has attempted to directly estimate agricultural export demand equations—specification error and simultaneous equation bias. Both may lead to biased estimates of the elasticity of export demand" (*25*, p. 10).

An examination of the literature on estimates of export demand for soybeans reveals few econometric estimations of longrun elasticities, with the exception of Chambers and Just (*6*) and Conway's (*7*) reestimation of their data. Thus, most of the soybean elasticity estimates in the literature emanate from annual or quarterly models, are short run, and reflect export responses to prices within that year or quarter. Such shortrun elasticity estimates are of limited value in U.S. policy analysis, where U.S. farm acts apply for 4 years or more and policymakers are concerned about even longer term policy effects on the U.S. agricultural sector.

Davison and Arnade are agricultural economists with the Commodity Economics Division and the Agriculture and Trade Analysis Division, ERS. Hallahan is an ERS mathematician with the Data Services Center. The authors thank ERS reviewers Ronald Babula, Nathan Childs, Praveen Dixit, Joseph Glauber, C.S. Kim, and Lloyd Teigen.

[1]Italicized numbers in parentheses cite sources in the References section at the end of this article.

Thompson's review of agricultural trade modeling in the literature concluded that it has made little, if any, contribution to shortrun forecasting. "Of the few modeling exercises that did list forecasting as an objective, almost none provided any forecasting performance measures out of the range of the data used to estimate the model" (*25*, p. 48). (Some recent U.S. agricultural trade studies have validated beyond the sample data, including articles by Babula (*2*) and Penson and Babula (*21*).)

We address these problems in the context of export demand for U.S. soybeans. First, we use the Box-Cox (*3*) family of power transformations to select a functional form for the estimating equations (addressing a source of specification error) and compare the results with results from more generally used linear and log-linear forms.

Second, we postulate that there are adjustment costs that will lead to differences between shortrun and longrun price and income elasticities for U.S. soybeans in major markets. We provide elasticity estimates that address the longer terms that concern U.S. producers and policymakers. Elasticity estimates from the Box-Cox estimation are compared with estimates from linear and log-linear equations.

Third, we evaluate out-of-sample forecasts of U.S. soybean exports from the linear, log-linear, and Box-Cox estimations.

Method

We assume soybeans are imported by profit-maximizing soybean processors that produce soybean meal and soybean oil. Meal can be imported directly or produced from imported beans. The domestic soybean meal (SM) supply from processing soybeans (SB) is:

$$SM = (1 - \theta)^*(SB), \quad (1)$$

where $1 - \theta$ is a technical coefficient reflecting the proportion of soybean meal obtained from crushing soybeans.

The domestic supply of soybean oil (SO) is:

$$SO = \theta^*(SB), \quad (2)$$

where θ is the proportion of crushed beans recovered as soybean oil. Since proportions of soybean oil and soybean meal may not be exact, a transformation function,

$$H(SM, SO) = SB, \quad (3)$$

reflects limited substitution possibilities between soybean oil and soybean meal.

Chambers (*5*) shows that a profit maximization problem can be broken into two steps. The first step is to maximize revenues subject to holding the input level constant, and then to choose the optimal level of input use in the second step. We find this manner of depicting the profit maximization problem useful. The solution to the first step is the revenue function:

$$R(PSO, PSM, SB) = \text{Max } [PSO*SO + PSM*SM], \text{ subject to: } H(SM, SO) = SB, \quad (4)$$

where PSO is the price of soybean oil and PSM is the price of soybean meal. Properties of the revenue function are discussed by Chambers (*5*) or Dixit and Norman (*9*). Profit maximizers then choose the optimal level of soybeans by:

$$\text{Max } R(PSO, PSM, SB) - PSB*SB \quad (5)$$

To depict the soybean processors, we add two features to this problem. We assume soybeans are imported, primarily from the United States. Competing suppliers primarily export soybeans and/or soybean meal. The second feature assumes adjustment costs to processing soybeans because processing is a relatively new industry in many countries.

Adjustment cost models have seen widespread acceptance in economics literature (*17, 28*). There are two popular methods to depict adjustment costs. One is to write the production process as a function of the level of inputs and changes in the level of some inputs. Productivity is assumed to decrease as inputs change, since adjustments from optimal input/output ratios temporarily hurt productivity (labor inputs at a processing plant may be less flexible than soybean input). The other manner of depicting adjustment costs is to explicitly portray them as a cost. This approach applies when companies explicitly pay higher costs as input variation increases or when lost output from adjustment is deemed a cost. We choose the latter approach and write the profit (π) maximization problem with quadratic nonnegative adjustment costs, or maximize π at time t where:

$$\pi = R(PSO, PSM, SB) - PSB*SB - \tau PSB[SB - SB_{t-1}]^2, \quad (6)$$

and τ is a fraction between 0 and 1, and SB_{t-1} refers to soybean use in the previous time period. The first-order condition to this profit maximization problem is:

$$\partial\pi/\partial SB = \partial R(PSO, PSM, SB)/\partial SB - PSB - 2\tau PSB[SB - SB_{t-1}]*[1-0] = 0 \quad (7)$$

Collecting terms at optimum is:

$$\partial R(PSO, PSM, SB)/\partial SB = PSB + 2\tau PSB[SB - SB_{t-1}], \quad (8)$$

where marginal revenue equals marginal cost (including marginal adjustment costs). Solving for SB gives the demand for soybean imports:

$$SB = d(PSB, PSM, PSO, SB_{t-1}) \quad (9)$$

We assume domestic soybean meal prices reflect world soybean meal prices. Domestic soybean oil prices, not generally available, can be expressed as a price-dependent domestic demand for soybean oil:

$$PSO = f(Y, SO), \quad (10)$$

where Y is domestic income. The transformation function (equation 3) suggests that equation 2 can be generalized as a production function,

$$SO = g(SB) \quad (11)$$

Substituting g(SB) for SO in equation 10 shows:

$$PSO = f(Y, g(SB)) \quad (12)$$

This equivalent of PSO can be substituted in equation 9 and arranged to solve for soybeans:[2]

$$SB = D(PSB, PSM, Y, SB_{t-1}) \quad (13)$$

Estimation

Major markets for U.S. soybean exports, identified by Stallings in constructing a trade-weighted exchange-rate index for U.S. soybean exports, include the EC-9, Japan, Spain, Taiwan, Mexico, South Korea, and Portugal. Using a linear form, we specified equation 13 for each of these major markets as:

$$SB_{it}^{(\lambda)} = b_0 + b_{1i}PSB_{it}^{(\lambda)} + b_{2i}PSM_{it}^{(\lambda)} + b_{3i}Y_{it}^{(\lambda)} + b_{4i}SB_{it-1}^{(\lambda)} + u_i, \quad (14)$$

[2]In solving for SB, we must assume that $\partial(\text{eqn } 9)/\partial PSO * \partial(\text{eqn } 10)/\partial SO * \partial(\text{eqn } 11)/\partial SB < 1$ to preserve the signs on the other variables.

where:

SB_{it} = U.S. soybean exports to the ith market (i = 1,. . .7) in time period t, in thousand metric tons;

λ = the Box-Cox power transformation parameter. The Box-Cox family of transformations provides a way to estimate the functional form for a model relating a dependent variable y and a set of regressor variables $x_1, \ldots, x_k$. For a positive variable W, the power transformation is defined as:

$$W^{(\lambda)} = (W^{\lambda}-1)/\lambda, \quad \lambda \neq 0,$$
$$= \ln(W), \quad \lambda = 0 \qquad (15)$$

In its most general form, y and each x_i are transformed by a (possibly) different parameter λ. In this study, we transform y and the x's by the same power. Special cases include the linear model, $\lambda = 1$, and the log-linear model, $\lambda = 0$. The parameter λ is estimated by maximum likelihood method, and approximate 95-percent confidence intervals for λ are obtained (fig. 1 and table 1) (*10*, p. 227). Maximum likelihood estimation of λ leads to the value of λ most compatible with having normally distributed errors.

PSB_{it} = U.S. soybean price in importer's deflated currency (dollars/metric ton * 1/U.S. CPI* foreign currency units/dollar * U.S. CPI/ foreign CPI);

PSM_{it} = U.S. soybean meal price in importer's deflated currency;

Y_{it} = real GDP in importing country (real GNP in Japan because real GDP was not available) in billions of foreign currency units (except Taiwan, which is in millions);

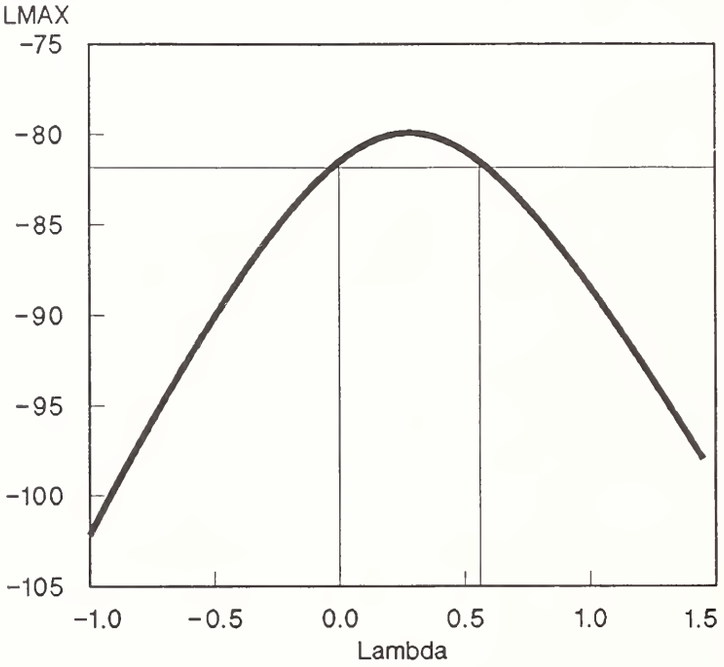
b_{ji} = parameters; and

u_i = normally distributed random errors.

Previous studies of export demand for U.S. soybeans have included in their explanatory variables the price of soybean meal as substitute for soybeans (*15, 16*), income in the importing countries (*6, 14, 15, 16*), exchange rates (*1, 6*), and lagged soybean exports (*6*).

Ordinary least squares (OLS) estimation of import demand equations for each of these markets would produce unbiased estimates in the presence of lagged endogenous variables if the errors are not correlated across time periods. However, because all our market equations involve U.S. soybean exports and the price of U.S. soybeans and soybean meal, market import demands may be contemporaneously correlated through the error (*2*, p. 14; *19*, p. 518) and OLS estimations may not be efficient. Consequently, we used Zellner's (*29*) seemingly unrelated regression

Figure 1
Selection of 95-percent confidence interval for lambda, Box-Cox transformation of U.S. soybean export data for Mexico



Vertical lines from the intersection of the curve and line determine the confidence interval. The horizontal axis ranges over values of λ for the Box-Cox transformation. The vertical axis, LMAX, is the maximum value of the log likelihood function for a given value of λ. Let $\hat{\lambda}$ be the value of λ producing the largest value of LMAX(λ). For Mexico, $\hat{\lambda}$=0.3. An approximate 95-percent confidence interval for λ consists of those λ satisfying the inequality $|LMAX(\lambda) - LMAX(\hat{\lambda})| = 1.92$. [$1.92 = 0.5\chi^2(1, 0.95)$] (*10*, pp. 225-35).

Table 1—95-percent confidence intervals for lambda (Box-Cox power transformation for dependent and exogenous variables)

Market	Lambda	
	Intervals	
EC-9	-1.30	0.45
Japan	-.40	3.00
Spain	[1]	[1]
Taiwan	-.85	1.70
Mexico	0	.55
South Korea	.45	.75
Portugal	-.15	.65

[1]Unable to calculate interval.

(SUR) to produce consistent, efficient, and unbiased estimates. SUR estimation required the same number of observations across all equations, which restricted the sample period to 1969-84 (exports to Portugal were zero before 1968). Finally, dynamic forecasts for 1985-87 were calculated.

Before SUR estimation, the linear ($\lambda = 1$), log-linear ($\lambda = 0$), and Box-Cox specifications were tested for serial correlation in the residuals from a test (suggested by Durbin (*11*)) asymptotically equivalent to Durbin's *h*. Evidence was insufficient at the 5-percent level to reject the null hypothesis that the errors are not correlated for each of the three specifications. We used the Box-Cox transformation and its maximization of log-likelihood functions to identify the best estimates of λ, within a range of -2 to $+2$, and then used Zellner's (*29*) SUR to estimate the parameters on the variables for all seven equations. Calendar year U.S. soybean export data, 1969-84, reported to the United Nations (*27*), were the dependent variables. Soybean and soybean meal prices, exchange rates, real GDP (GNP), and CPI indexes came from the International Monetary Fund's (IMF) *International Financial Statistics* (*18*) and Taiwan's statistical counterparts (*4, 8*).

Results

The following sections present linear, log-linear, and Box-Cox estimations of the equations and price and income elasticities, followed by an evaluation of the forecasting performance of the linear, log-linear, and Box-Cox equations.

Equation Estimates

Tables 2, 3, and 4 show the linear, log-linear, and Box-Cox estimating equations for all seven markets. We expected plausible signs for three variables: soybean price, negative (own price); soybean meal price, positive (price of output or substitute); and income, positive. Soybeans are inputs for soybean processors, whose outputs are soybean meal and soybean oil. Input demands are negative in own-price and positive in output (soybean meal) prices. Processors could import soybean meal directly, bypassing the processing, making the soybean meal a substitute for soybeans.

The Box-Cox version of the Portugal equation appears less appealing than the linear version because of the implausible signs on soybean and soybean meal prices (although not significant in either estimation) and the lower R^2 values. Otherwise, in terms of plausible signs and R^2 values, the Box-Cox equations perform as well as or better than the linear or log-linear alternatives. Since the Box-Cox transformation finds that model (in the family of power-transformed models) where normality of the error terms is "most likely," the Box-Cox estimates produce more valid t-values than the linear or log-linear models. The Mexico equation produced implausible signs on both price variables in all three (linear, log-linear, and Box-Cox) estimations, although these variables were not statistically significant in any of the three estimations (we did not find multicollinearity among the variables).

Table 2—SUR estimation results for U.S. soybean export equations, 1969-84, linear[1]

Variables/data	EC-9	Japan	Spain	Taiwan	Mexico	South Korea	Portugal
Constant	-5,904	708	463	357	-916	-117	-87.6
	(-1.68)	(1.28)	(.63)	(2.08)	(-2.26)*	(-1.55)	(-.50)
Real U.S. soybean price, Rotterdam[2]	-8.53	-.008	-.037	-.0001	.074	-.002	-.008
	(-1.12)	(-1.36)	(-1.72)	(-.58)	(1.04)	(-2.78)**	(-.68)
Real U.S. soybean meal price, Rotterdam[2]	6.27	.008	.013	.00005	-.079	.001	.003
	(.85)	(1.60)	(.61)	(.29)	(-1.12)	(2.34)*	(.30)
Real GDP in importing country[3]	7.17	.014	.128	.0007	.368	.013	.231
	(2.88)**	(3.81)**	(2.50)*	(5.61)**	(3.21)**	(4.52)**	(1.73)
Imports of U.S. soybeans, t-1	.080	-.045	.020	-.394	.051	.368	.801
	(.36)	(-.22)	(.11)	(-1.99)	(.17)	(2.59)*	(6.10)**
R^2	.74	.88	.67	.84	.62	.95	.86

[1]t-values in parentheses. Significance levels (one-tailed test with 11 degrees of freedom, two-tailed test for constant and lagged soybean imports): * = 5 percent, ** = 1 percent.
[2]Jan.-Dec. average, importer's currency units per metric ton, deflated by U.S. and importer's CPI's.
[3]Real GNP for Japan, for which real GDP was not available.

Table 3—SUR estimation results for U.S. soybean export equations, 1969-84, log-linear[1]

Variables/data	EC-9	Japan	Spain	Taiwan	Mexico	South Korea	Portugal
Constant	-3.31	-4.12	3.55	-0.586	-41.7	-74.3	-8.65
	(-.72)	(-1.98)	(.90)	(-.20)	(-4.00)**	(-3.94)**	(-.85)
Real U.S. soybean price, Rotterdam[2]	-.390	-.191	-.710	-.269	2.71	-1.08	1.00
	(-1.23)	(-1.11)	(-1.75)	(-.79)	(1.35)	(-.39)	(.67)
Real U.S. soybean meal price, Rotterdam[2]	.366	.230	.016	.046	-2.82	2.28	-2.72
	(1.23)	(1.49)	(.04)	(.15)	(-1.46)	(.84)	(-2.26)
Real GDP in importing country[3]	1.12	1.11	1.12	.833	6.12	6.41	4.12
	(1.27)	(6.39)**	(2.69)*	(4.80)**	(5.42)**	(5.84)**	(3.00)**
Imports of U.S. soybeans, t-1	.446	-.219	.027	-.190	-.427	-.310	.185
	(1.69)	(-1.67)	(.15)	(-1.13)	(-2.20)*	(-1.96)	(.90)
R^2	.84	.87	.79	.84	.67	.72	.83

[1]t-values in parentheses. Significance levels (one-tailed test with 11 degrees of freedom, two-tailed test for constant and lagged soybean imports): * = 5 percent, ** = 1 percent.
[2]Jan.-Dec. average, importer's currency units per metric ton, deflated by U.S. and importer's CPI's.
[3]Real GNP for Japan, for which real GDP was not available.

Table 4—SUR estimation results for U.S. soybean export equations, 1969-84, Box-Cox[1]

Variables/data	EC-9	Japan	Spain	Taiwan	Mexico	South Korea	Portugal
Constant	-0.006	4,092	1.01	9.96	-55.8	-34.9	-18.1
	(-.02)	(2.03)	(.32)	(2.00)	(-2.99)*	(-2.90)*	(-1.34)
Real U.S. soybean price, Rotterdam[2]	-.041	-.005	-6.77	-.030	.760	-.033	.190
	(-1.07)	(-1.74)	(-2.22)*	(-.81)	(1.26)	(-4.20)**	(.49)
Real U.S. soybean meal price, Rotterdam[2]	.043	.005	-.245	.008	-.850	.026	-.507
	(1.25)	(1.87)*	(-.09)	(.25)	(-1.43)	(3.53)**	(-1.58)
Real GDP in importing country[3]	.648	.006	7.56	.105	2.18	.107	1.95
	(1.85)*	(4.64)**	(4.26)**	(4.74)**	(3.89)**	(6.68)**	(2.73)**
Imports of U.S. soybeans, t-1	.358	-.125	-.259	-.320	-.237	.260	.338
	(1.74)	(-.76)	(-1.61)	(-1.56)	(-.87)	(2.40)*	(1.69)
R^2	.87	.88	.82	.85	.71	.96	.84
λ[4]	-.65	1.2	-.7	.3	.3	.6	.25

[1]t-values in parentheses. Significance levels (one-tailed test with 11 degrees of freedom, two-tailed test for constant and lagged soybean imports): * = 5 percent, ** = 1 percent.
[2]Jan.-Dec. average, importer's currency units per metric ton, deflated by U.S. and importer's CPI's.
[3]Real GNP for Japan, for which real GDP was not available.
[4]Estimated coefficient used to transform original data.

Elasticity Estimates

Table 5 contains shortrun and longrun own-price and income elasticities calculated from the linear, log-linear, and Box-Cox equations. Some longrun price and income elasticity estimates are less elastic than the shortrun estimates, suggesting the possibility of overshooting or overreacting to prices in the short run.

Our shortrun Box-Cox soybean price elasticity estimate (-0.23) for Japan is lower than Greenshield's (*13*) -0.65 (annual data, 1955-73, price variable = deflated import price index) and the -0.35 estimate by Meyers and others (*20*) (annual data, 1960/61-1976/77, elasticities for 1973/74-1976/77; price variable = soybean wholesale price index in Japan). Our shortrun Box-Cox income elasticity estimate (0.88) for Japan is

Table 5—Price and income elasticities for U.S. soybean exports

Market	Own-price elasticities[1]			Income elasticities[1]		
	Linear	Log	Box-Cox	Linear	Log	Box-Cox
Short run:						
EC-9	-0.36	-0.39	-0.33	1.94	1.12	1.51
Japan	-.21	-.19	-.23	.86	1.11	.88
Spain	-.80	-.71	-.80	1.23	1.12	1.55
Taiwan	-.19	-.27	-.27	1.06	.83	.95
Mexico	1.43[2]	2.71[2]	1.85[2]	2.99	6.12	4.08
S. Korea	-1.23	-1.08	-1.78	1.55	6.41	1.90
Portugal	-.74	1.00[2]	.59[2]	1.32	4.12	3.02
Long run:						
EC-9	-.39	-.71	-.51	2.11	2.02	2.36
Japan	-.20	-.16	-.20	.82	.91	.78
Spain	-.81	-.73	-.63	1.25	1.15	1.23
Taiwan	-.14	-.23	-.21	.76	.70	.72
Mexico	1.51[2]	1.90[2]	1.49[2]	3.15	4.28	3.30
S. Korea	-1.95	-.83	-2.40	2.45	4.90	2.57
Portugal	-3.69	1.23[2]	.89[2]	6.62	5.06	4.56

[1]Calculated at the sample means.
[2]Implausible sign.

close to Greenshield's (*13*) 0.81 estimate (income variable = per capita private consumption expenditure index at constant prices).

Forecast Errors Outside the Sample

The forecasting performance of the linear, log-linear, and Box-Cox estimators is summarized in absolute percentage errors in table 6. Actual, not predicted, values of the exogenous variables were used to forecast U.S. soybean exports, but predicted values of the lagged dependent variable were used. The naive forecasts are the previous year's exports.

The linear equations gave better forecasts than the Box-Cox or log-linear equations when forecasts were averaged across markets, but none was better than the naive forecast. Although the equations for Mexico produced the poorest fits in all three estimations, their forecasts, when averaged, consistently surpassed the naive model. Equation forecasts for Taiwan also averaged better than the naive model, as did the linear and Box-Cox forecasts for South Korea.

U.S. soybean exports in 1984 and 1985 were hurt by increased soybean exports from Brazil and Argentina. The exchange rate of the U.S. dollar relative to these

Table 6—Absolute percentage errors and mean absolute percentage errors (MAPE's): U.S. soybean export projections, 1985-87

Estimator/ year	EC-9	Japan	Spain	Taiwan	Mexico	South Korea	Portugal	Mean
				Absolute percentage error				
Linear:								
1985	73.9	8.3	74.2	3.6	4.3	8.9	22.6	28.0
1986	47.9	17.0	33.6	10.3	2.5	9.8	29.6	21.5
1987	51.4	32.2	[1]	8.9	[1]	5.6	29.6	25.5
Mean	57.7	19.2	53.9	7.6	3.4	8.1	27.2	
Log:								
1985	39.4	6.8	84.4	3.5	13.7	54.8	78.3	40.1
1986	31.0	16.1	64.7	9.5	36.8	222.9	99.4	68.6
1987	46.9	32.2	[1]	7.2	[1]	347.9	128.2	112.5
Mean	39.1	18.4	74.6	6.7	25.2	208.5	101.9	
Naive:								
1985	15.5	3.6	37.8	3.3	64.4	19.9	17.6	23.2
1986	23.7	4.2	33.5	21.7	18.6	18.2	3.8	17.7
1987	3.1	8.5	[1]	7.3	[1]	11.1	9.3	7.9
Mean	14.1	5.4	35.6	10.8	41.5	16.4	10.2	
Box-Cox:								
1985	41.5	8.8	118.6	3.0	.8	4.8	29.0	29.5
1986	36.0	16.5	195.0	10.0	14.3	6.2	33.2	44.5
1987	57.0	31.5	[1]	8.8	[1]	18.5	37.4	30.6
Mean	44.8	18.9	156.8	7.3	7.5	9.8	33.2	

[1]1987 GDP data not available for Spain and Mexico.

two competitors' currencies was higher in 1984 and 1985 than it has been before or since, and was also higher relative to currencies of importers of U.S. soybeans (*24*). Our linear, log-linear, and Box-Cox specifications did not include exports or exchange rates of U.S. competitors, which helps explain the forecast errors for 1985.

Forecasts from the Box-Cox estimations, when averaged across markets, performed better than those from the log-linear estimations, which may be commonly employed because of the convenience in estimating elasticities. Although many of the naive model forecasts are relatively appealing, econometric estimation provides additional information not available from the naive model. Estimation provided policy-relevant price and income elasticity estimates, as well as statistical indications of the relative importance of variables influencing U.S. soybean exports.

Conclusions

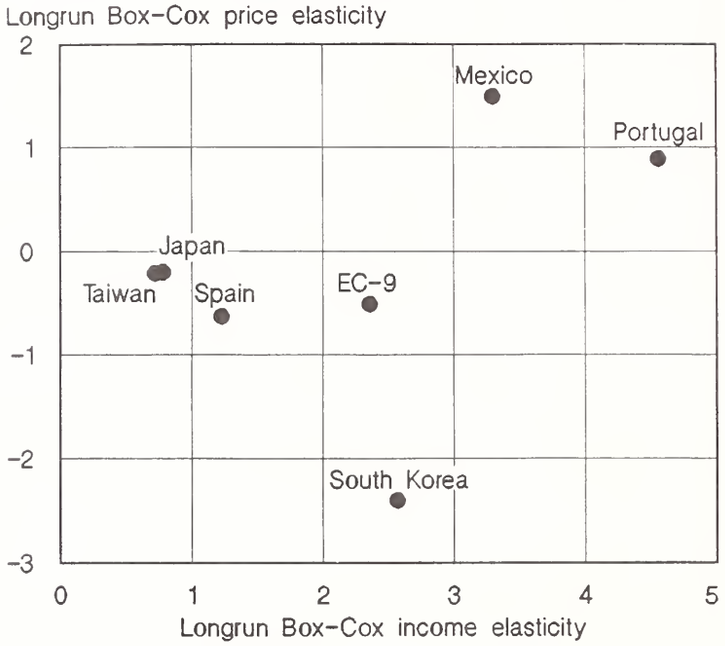
Box-Cox transformations provide approximately normally distributed error terms, which are often simply assumed for the more frequently used linear or log-linear forms (which are nested within the Box-Cox framework). This condition is important for hypothesis testing, such as t-tests of significance for variables, and estimating confidence intervals. Functional form selection appreciably affected forecasts outside the sample and the elasticity estimates. Longrun price and income elasticity estimates range from elastic to inelastic in these seven major markets.

Policy Implications

This multiple-market approach provides information, including price and income elasticity estimates, that could help policymakers and exporters tailor export marketing strategies to fit specific markets. For example, arraying the U.S. soybean markets identified in this analysis in a matrix according to estimates of their Box-Cox longrun price and income elasticities may illustrate which countries are price sensitive (price elasticity greater than –1.00) and which are income sensitive in purchasing U.S. soybean exports (fig. 2).

Income-sensitive markets may be more responsive to credit guarantee programs, such as GSM-102, which maintain or expand the demand for U.S. exports in markets with tight foreign exchange constraints (*22, 26*). If the International Monetary Fund or commercial banks increase lending to developing countries, those that are income sensitive might respond by boosting their imports of U.S. soybeans.

Figure 2
Sensitivity of U.S. soybean exports to changes in importer's price and income, by major U.S. soybean markets, 1969-84



An SAS macro to estimate the parameters for the Box-Cox transformation is available from Charlie Hallahan, (202) 786-1507. The macro uses the IML matrix language in PC/SAS. Some options in the macro are: estimate the OLS linear and/or log-linear models (for comparison); compute elasticities at the mean for each model estimated; transform the independent variables as well as the dependent variables (all variables transformed using the same power). The macro uses first derivative information to calculate asymptotically correct standard errors for all estimated parameters. Planned enhancements include the use of second derivatives for standard errors and normality tests for residuals.

If U.S. soybean export expansion were desired, price-sensitive markets might be good candidates for export programs with strong price-subsidy elements, such as the Export Enhancement Program (EEP), designed to make U.S. exports more price competitive in specific markets (*22, 26*). If trade liberalization lowers world soybean prices, countries more sensitive to price changes may become faster growing export markets.

Other programs may help develop demand for American products by influencing tastes and preferences in markets that are relatively insensitive to price or income changes. For example, the Cooperator Program,

a joint effort by the U.S. Government and producer groups, involves trade fairs and demonstration projects (*23*). The Targeted Export Assistance (TEA) Program attempts to influence consumer preferences by either creating product awareness and good will or by establishing product differentiation (*26*). The TEA Program promotes exports of a specific category or brand of American commodity or products in specified markets (*22*).

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Productivity of Highly Erodible Cropland

Ralph E. Heimlich

Abstract. *The notion that highly erodible soils are uniformly unproductive is not supported by empirical evidence. Thus, the presumption that the cost of conservation programs targeted at highly erodible land will be low is erroneous. Average net crop revenue on nonirrigated highly erodible cropland is less than on nonerodible land, but the productivity distributions across these erodibility classes are nearly equal. Significant acreages with all but the highest productivity can be found at all levels of erodibility. Retiring highly erodible, physically marginal cropland is not synonymous with retiring less productive, economically marginal cropland.*

Keywords. *Soil productivity, soil erodibility, soil erosion policy, U.S. cropland.*

An apparent assumption in some analyses of soil conservation policies is that highly erodible land has low productivity (*3*, p. 91; *5*, p. 39; *16*, pp. 4-14).[1] An example of the presumed relationship between economic productivity and erodibility is the following:

> As more farmland is converted to other uses, marginal farmland will be brought into production. The pollution potential from this land is higher because marginal land is generally more erodible than other farmland. (*15*, p. 5)

Assuming that highly erodible cropland is uniformly less productive than other cropland, as the policy analysts cited above apparently do, may lead to serious underestimates of costs of programs targeted at highly erodible cropland (*7*). Current agricultural policy, through the conservation reserve and conservation compliance provisions of the Food Security Act of 1985 (P.L. 99-198), seeks to retire highly erodible land or deny farm program subsidies to operators who crop such land. These policies are broad and general, applied to all highly erodible cropland and not differentiated either by region or for exceptionally productive highly erodible land. However, if some highly erodible land has high current productivity, meeting conservation reserve enrollment targets and compliance objectives will have higher monetary and opportunity costs than previously assumed. This paper empirically tests the hypothesis that highly erodible cropland is less productive than other land.

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[1]Italicized numbers in parentheses cite sources listed in the References section at the end of this article.

The statements cited above confuse physical and economic concepts of resource marginality. Soil scientists and agronomists focus on physical attributes of land which limit its usefulness for sustained crop production. Such physical properties as soil moisture, texture, acidity, depth, slope, porosity, organic matter content, temperature, and nutrient-holding capacity figure prominently in physical assessments of soil resources (*15*). Highly erodible land has been identified in recent policy as physically marginal land that should be retired from crop production.

In contrast to this concept of marginal land, economic theory suggests that factors of production, including land, will be used in a competitive environment as long as the marginal benefits from use exceed the marginal costs. Land that produces low crop yields can become economically marginal as crop prices decrease or production costs increase, even if there are few physical limitations that prevent its use for crop production. Conversely, even land with severe physical limitations for long-term crop production will be farmed at a given crop price if it has high enough yields to cover variable costs of production (marginal cost curve above average variable cost curve) in the short run. Different land resources are at the economic margin at different times because crop prices, production costs, and technology change over time.

Policymakers find appealing the notion that if erodible soils are economically marginal, current production will be less affected, but gains in the present value of future production and reduced off-site damages will occur. This notion is abetted by mental telescoping of erosion's effects over time to a conclusion about the current productivity of erodible land. However, results of long-term erosion impact studies do not preclude the possibility that conditions of topography, soil texture, and climate that lead to high soil erosion can be found across the entire range of current productivity levels (*1, 4, 11, 17*).

Bills (*2*) previously investigated relationships between productivity and erodibility of New York soils. He found that soil erodibility was not highly correlated with crop yields and that average corn yields were similar for land in all erodibility classes. This study extends the investigation to all nonirrigated U.S. cropland (*8*).

Data and Methods

This study merges information from the 1982 National Resources Inventory (NRI) conducted by the Soil Conservation Service (SCS), the Soil Interpretation Record (SOILS 5), and the Firm Enterprise Data System (FEDS) crop budgets, with an erodibility classification developed previously. In the NRI, data on 251,430 nonirrigated cropland observations provided land capability class, prime land, soils information, and erosion equation parameters used to calculate the erodibility index. Predicted yields of crops approximating those obtained by leading commercial farmers at the level of management which tends to produce the highest economic returns per acre are recorded on the SOILS 5 computer data base by SCS for all established soil series (*14*). Estimated crop yields for major field crops contained on the SOILS 5 record were matched to the NRI record pertaining to each sample point (*13*).

Firm Enterprise Data System (FEDS) Crop Budgets—Periodic surveys of farm operators produce data on farm production expenditures and technical relationships for major agricultural commodities. FEDS budgets in each State were prepared at Oklahoma State University for research purposes that were also partially based on these data (*10*). FEDS budgets and season-average commodity prices for 1982 were used in this study.

Because fixed costs of production, such as charges for land, buildings, and the machinery complement, depend heavily on the size of the operation and the mix of enterprises on which they are used, input costs used in this analysis are restricted to variable costs. FEDS production costs only imperfectly reflect variation in costs due to resource differences because they were prepared for wide geographic areas.

Physical and Economic Productivity Measures—One possibility for a productivity measure is the physical yield of a ubiquitous indicator crop, such as corn grain. However, corn yields are not reported by SCS on soils where corn is not commonly grown, despite the fact that physical conditions may be appropriate for corn production. Corn yields were estimated for only about 67 percent of nonirrigated cropland soils. As Gersmehl and Brown (*6*) have shown, yields for important crops are often not correlated with each other on the same soil.

Weighting the yields of various crops that could be grown on the soil circumvents this problem by incorporating all the yield information available into a single economic measure. This is a more complete measure than corn grain yield since yields for at least one of the major field crops are reported on more than 99 percent of cropland. Soil productivity, as distinguished from crop yield, is measured by the relationship between outputs and inputs necessary to obtain those outputs, so simple average net crop revenues at each NRI sample point were calculated using the following formula:

$$NR = \left(\sum_{i=1}^{n} Q_i * P_i - C_i\right)/n,$$

where NR = net revenues from crop production of the eight major field crops at the sample point;
Q_i = crop yield of the ith crop;
P_i = price per unit of the ith crop;
C_i = variable production cost of the ith crop; and
n = the number of crops with nonzero yield.

Assessing Cropland Erodibility—Heimlich and Bills (*9*) used the universal soil loss equation (USLE) to partition cropland into classes based on physical characteristics and the cropping system. Land with climate and topography such that erosion above tolerable levels occurs under any practical cropping system short of permanent grass was defined as highly erodible. Land that can meet tolerable soil loss limits under all cropping systems was called nonerodible. The remainder, termed moderately erodible, is land which may or may not erode excessively depending on how it is managed. I calculated this measure of inherent soil erodibility from USLE parameters contained on each NRI record. I segregated wind erodible land into a separate class because parameters of the wind erosion predictive equation were not available. Numerical limits to the classes are as follows:

Nonerodible	$[RK(LS)]/T \leq 2$;
Moderately erodible:	
Managed to erode below T	$2 \leq [RK(LS)]/T < 15$ and $A < T$;
Managed to erode above T	$2 \leq [RK(LS)]/T < 15$ and $A < T$;
Highly erodible	$[RK(LS)]/T \geq 15$; and
Wind erodible	$W > T$,

where the rainfall erosion index (R), soil erodibility index (K), topographic factor (LS), and the soil loss tolerance value (T) are all parameters of the USLE, A is the estimated rate of sheet and rill erosion, and W is the estimated rate of wind erosion using the wind erosion equation.

Results

Continuous measures of soil productivity based on recorded corn grain yields and estimated net returns from nonirrigated production of major field crops are

not correlated with a continuous measure of soil erodibility (table 1). Correlation between productivity measures, land capability class, and the prime farmland definition is weak. The corn grain yield measure of soil productivity is positively correlated with the net revenue measure, but only weakly.

On average, nonerodible land can generate higher current net revenue than highly erodible land, although the difference is small (table 2). Moderately erodible land produces the highest average net revenue. Differences in mean net revenue by erodibility classes are statistically significant in all cases.

Table 1—Correlation matrix and statistics for nonirrigated cropland productivity, erodibility, and land classification variables, 1982

Variables	RKLS/T	Corn yield	Net crop revenue	Land capability	Prime farmland
RKLS/T[1]	1.000	—	—	—	—
Corn yield	-.110	1.000	—	—	—
Net crop revenue	-.059	.337	1.000	—	—
Land capability	.318	-.385	-.371	1.000	—
Prime land	-.187	.350	.394	-.620	1.000
Mean	6.19	92.15	6.66	2.66	1.46
Standard deviation	59.14	99.71	183.81	4.03	1.89
Minimum	0	40.00	-254.14	1.00	0
Maximum	1,535.56	163.00	246.57	8.00	1.00

— = Symmetrical entries across the main diagonal of the matrix.
[1]Continuous variable computed using USLE parameters at each 1982 NRI sample point.

Table 2—Mean net crop revenue and distribution of nonirrigated cropland acreage, by net crop revenue and erodibility, 1982

Net crop revenue	Erodibility class					
	Non-erodible	Moderately erodible		Highly erodible	Wind erodible	All cropland
		Below T	Above T			
				Dollars per acre		
Mean	7.86	15.70	21.34	1.58	-24.63	6.66
				1,000 acres		
No yield	246	263	96	289	366	1,260
Less than -50	14,508	6,682	4,759	4,961	12,998	43,907
-50 to -26	21,166	7,523	4,192	3,722	16,064	52,667
-25 to 0	17,336	14,538	9,650	7,306	12,226	61,055
1 to 25	24,413	21,914	18,420	6,453	8,425	79,626
26 to 50	22,141	15,674	14,193	4,381	3,466	59,854
51 to 75	12,226	8,344	7,747	2,726	1,139	32,182
More than 75	10,457	8,356	7,663	2,719	344	29,539
Total[1]	122,493	83,294	66,719	32,557	55,027	360,090
				Percent		
No yield	0.2	0.3	0.1	0.9	0.7	0.3
Less than -50	11.8	8.0	7.1	15.2	23.6	12.2
-50 to -26	17.3	9.0	6.3	11.4	29.2	14.6
-25 to 0	14.2	17.5	14.5	22.4	22.2	17.0
1 to 25	19.9	26.3	27.6	19.8	15.3	22.1
26 to 50	18.1	18.8	21.3	13.5	6.3	16.6
51 to 75	10.0	10.0	11.6	8.4	2.1	8.9
More than 75	8.5	10.0	11.5	8.4	.6	8.2
Total[1]	100.0	100.0	100.0	100.0	100.0	100.0

[1]Columns may not add to totals due to rounding.

The difference in average net revenue between highly erodible and nonerodible cropland, while statistically significant, has no practical importance in light of the productivity distributions of land in each erodibility class. The distribution of net revenue for highly erodible land is similar to the distribution for nonerodible land, and there is almost complete overlap in the distributions. While the largest portion of the cropland with more than $75 per acre in estimated net revenue is nonerodible (35 percent), more than 9 percent of such land is highly erodible, proportional to the percentage of all cropland that is highly erodible. Highly erodible land, moderately erodible land managed to erode above T, and wind erodible cropland make up more than 36 percent of all high-return cropland.

In absolute terms, about one-third of nonirrigated cropland with negative estimated returns is nonerodible and only 10 percent is highly erodible, proportional to their contribution to all cropland. Only wind erodible cropland has a higher proportion of nonirrigated cropland with negative net revenue. Arid areas more affected by wind erosion generally also have low nonirrigated crop yields. Two-thirds of wind erodible cropland that was irrigated in 1982 had positive estimated net revenue as irrigated cropland.

Factors Affecting Productivity

Relationships between attributes of the land and productivity cannot be adequately shown using simple correlations and cross-tabulations. Multiple linear regression can help decompose the relative contributions of these attributes toward the soil's productivity. The regression model discussed here takes the form:

$$Y = B_1D_1 + B_2D_2 + B_3D_3 + B_4D_4 + u,$$

where
- Y = either corn grain yield or crop revenue measures of soil productivity;
- D_1 = vector of dummy variables for soil erodibility classes, 5 levels;
- D_2 = vector of dummy variables for land capability classes, levels I through VIII;
- D_3 = vector of dummy variables for land capability subclasses, levels c through w;
- D_4 = dummy variable for USDA prime farmland, 2 levels;
- B_1-B_4 = vector of coefficients for each level of each of the dummy independent variables.
- u = an error term measuring variation in productivity unaccounted for by the independent variables.

The independent variables are all discrete categorical variables that show what class of the particular attribute (erodibility, capability, hazard, "primeness") the observation on the dependent variable fits. The estimated coefficient for each level of each attribute adds or subtracts from the mean productivity (table 3). For example, average net crop revenue on nonerodible prime land in class II with an erosion hazard is estimated to be –$43.54 +57.53 – 24.16 +17.65 =$7.48.

The explanatory power of the yield regression model is good, with more than 94 percent of the variance in corn grain yield accounted for by the model (R^2 = 0.943). The same independent variables account for only about 30 percent of total variance in net revenue. These soil attributes are only proxies for the underlying physical factors that determine productivity. A serious attempt to model soil productivity would make use of data on these underlying factors available in the SOILS 5 file. This article's models help us see the relationship of each of these classification systems to soil productivity, controlling for the presence of the other classification systems.

In both the yield and net revenue models, erodibility actually adds more to average productivity than nonerodibility. That is, the average productivity on highly erodible land is higher than that for nonerodible land, other factors held constant. Moderately erodible land managed to erode above T has the second highest productivity, while wind erodible soils have the lowest productivity.

In both the yield and net revenue models, capability classes and subclasses into which land is grouped based on the kind of hazard or limitation to cropping are associated with reductions in productivity, other factors being equal. Class I land is more productive than is apparent since, by definition, it has no subclass to further reduce average productivity, while all other classes must have a subclass rating. The apparent contradiction between the large productivity reduction associated with the erosion hazard subclass and the large addition to productivity associated with highly erodible land may be explained in part by recalling that subclass e is first in the hierarchy of limitations. If land is not rated class I and no other limitation is judged dominant, subclass e is assigned. Thus, 51.7 percent of cropland inventoried in 1982 was in subclass e, although only 7.1 percent of all cropland was highly erodible (*9*).

Conclusions and Implications

The current productivity of highly erodible soils is not uniformly low. Average net revenue on highly erodible land is lower than on nonerodible land, and the

Table 3—General linear model estimates of contributions to nonirrigated cropland productivity, 1982[1]

Variable	Corn grain yield		Net crop revenue	
	Parameter (Bi)	Standard error	Parameter (Bi)	Standard error
Erodibility:				
Nonerodible	137.3	2.43	–43.54	2.50
Moderately ≤ T	134.2	2.43	–32.72	2.50
Moderately > T	139.6	2.43	–24.24	2.50
Highly	142.5	2.43	–18.31	2.50
Wind	126.7	2.43	–58.95	2.50
Land capability class:				
I	–23.2	2.43	67.67	2.51
II	–31.3	2.43	57.53	2.50
III	–46.6	2.43	47.68	2.50
IV	–55.8	2.43	35.79	2.50
V	–52.4	2.45	30.95	2.52
VI	–46.3	2.44	20.74	2.51
VII	–39.8	2.45	11.23	2.52
VIII	0	na	0	na
Land subclass:				
c	–42.8	.10	–33.81	.10
e	–12.5	.04	–24.16	.06
s	–25.8	.06	–17.35	.09
w	0	na	0	na
Prime farmland:				
Prime	2.3	.04	17.65	.06
Nonprime	0	na	0	na
R-square	0.943		0.301	

na = not applicable.

[1]Statistical Analysis System (SAS) General Linear Models (GLM) procedure with categorical variables produces a singular X'X matrix and uses a generalized inverse to solve the normal equations. All parameter estimates are biased but are best linear unbiased estimates (BLUE) for some linear combination of the parameters (*12*). All parameters are significantly different from zero at the 99-percent confidence level.

difference is statistically significant. However, policy is not applied "on the average" and the same proportion of highly erodible soils are highly productive as for nonerodible soils. Because the productivity distributions of highly erodible and nonerodible land are nearly equal, there is no practical significance to differences in average productivity. The proportion of highly productive, highly erodible soils is not significantly less than for nonerodible soils, in terms of either corn grain yield or net crop revenue from common field crops.

This conclusion is an important one for current conservation policy because current productivity determines the cost of retiring highly erodible land. Policy and program decisions designed to affect use of erodible land cannot presume that this land has low opportunity costs. While erodible land may or may not earn lower revenue over the long term, incentives required to restrict production in the short term must be based on current productivity. Since current productivity is uncorrelated with erodibility, idling some highly erodible land may also idle some of our most productive and valuable cropland. If so, retirement incentives may have to be correspondingly large or other kinds of physically marginal land may have to be identified to meet acreage goals.

Further research is needed to make better use of existing soil information for policy evaluation. From a longer term public policy perspective, it is important to know the productivity of highly erodible soils in both current terms and in terms of longrun losses. Although continued erosion may decrease yields in the long run, establishing evidence for that relationship is beyond the scope of this study.

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Farmgate, Processor, and Consumer Price Transmissions in the Wheat Sector

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Abstract. *Time series techniques (vector autoregression or VAR) are employed to model a three-price dynamic system of the farmgate, processor, and consumer prices of wheat-related goods. An increase (presumably drought-induced) in farmgate wheat price is simulated to determine impacts on processor and consumer prices in the wheat sector. Several findings emerge. First, the increase in farm wheat price (PF-increase) may be expected to immediately generate processor price increases which are statistically significant for almost a year. Second, the PF-increase is expected to generate wheat-related consumer price increases, which are mostly significant for 22 months. Consumer price increases of wheat-related goods are expected to peak in strength at about the 8-month point following the PF-increase. And third, the consumer price increases are expected to be more gradual, less acute, but of longer duration than the processor price rises.*

Keywords. *Vector autoregression (VAR); Kloek-Van Dijk t-values; drought; decompositions of forecast error variance; farmgate, processor or industrial, and consumer prices of wheat-based goods; farm/nonfarm price transmissions.*

The year 1988 was one of serious drought for American agriculture. The drought's grain supply shortfalls have bolstered grain prices (*14*, p. 37).[1] By midsummer, prices of grain and grain-related products had already risen because of preharvest speculation and expectations (*9*). Looker (*9*) writes that, at that time, some had contended that "in nearly 20 years in the grocery business, [they] had never seen anything quite like the price increases announced. . . . Anything that's got grain. . . . seemed to be costing more as the drought scare pushed up commodity prices." Such statements indicate the casual observation and do not speak to the dynamics of price transmissions. It is this dynamic process that farmers, food processors, consumers, and policymakers need to understand in order to make reasonable planning decisions when faced with a particular farm-level price shock. An example of such a shock is the 1988 drought's rise in wheat price at the farmgate.

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[1]Italicized numbers in parentheses cite sources listed in the References section at the end of this article.

We use time series techniques and construct a vector autoregression (VAR) model of a dynamic system of wheat-related farmgate, processor, and consumer prices. Using this VAR model, we glean the empirical regularities from time-ordered data on these prices, gaining insight on the nature of the transmission mechanisms among these three wheat sector price levels. We specifically trace through the impacts, on wheat-related processor and consumer prices, of a presumably drought-induced rise in farmgate wheat price. Not specifically emphasized are the price effects of the 1988 drought, as done by Babula and Bessler (*1*). Rather, we demonstrate how one may use VAR econometrics and revealed empirical regularities about wheat-related prices to analyze how a "generic" farmgate increase in wheat price pulsates through the industrial and consumer sectors for wheat-based goods. We presume the generic rise in wheat price to be drought induced.

This study has several objectives. We first estimate a VAR model of the wheat sector's system of farmgate, processor (or industrial), and consumer prices. Second, we shock the VAR model with a rise in farm wheat price and analyze the impulse response patterns in processor and consumer prices of wheat-based products. This analysis demonstrates how, and for how long, the presumably drought-induced rise in farmgate wheat price is expected to influence processor and consumer prices in the wheat sector. The Kloek-Van Dijk procedure generated t-values for each impulse response to demonstrate how statistically significant (hereafter, significant) these impulses were (*7*). Third, we obtain and analyze decompositions in forecast error variance (FEV) for the model's three variables. These analyses provide insight into the nature and the strength of the interrelationships among wheat-related farm, processor, and consumer prices. Such analyses uncover past data's empirical regularities and indicate how the time-ordered series have moved through time. These past trends suggest how history would have wheat-related industrial and consumer prices respond to such a current farm sector price shock as the 1988 drought's increases in farm wheat price.

VAR Econometrics

Under rather general conditions, an m-component vector, indexed by time period t, admits an autoregressive representation generally expressed as relation 1

(*11*). (Note: bold-faced characters represent matrices or vectors.)

$$\mathbf{x}(t) = (\text{SUM}(s = 1,\text{inf}))[\mathbf{b}(s)*\mathbf{x}(t-s)] + \mathbf{e}(t) \quad (1)$$

Here, SUM(s = 1,inf.) is the summation operator for variable "s" over the range of 1.0 through infinity (inf.). The "s" denotes the lag order. The **b**(s) are m*m matrices of autoregressive (AR) regression coefficients and **e**(t) is an m-element vector of white noise residuals (or innovations). The white noise nature of **e**(t) satisfies equations 2 and 3 (*2, 3, 4*).

$$E(\mathbf{e}(t)) = \mathbf{0} \text{ for all t, and} \quad (2)$$

$$E(\mathbf{e}(t)\mathbf{e}(s)') = \mathbf{0} \text{ if t does not equal s; } = \mathbf{S}, \quad (3)$$

a positive definite, m*m covariance matrix, for t = s,

where "E" signifies the best linear predictor. For applied work, relation 1's infinite lag sequence must be truncated to a number small enough to be operational but large enough for the residuals to approximate white noise (*2*, p. 112). A universally accepted method of VAR lag selection, however, does not exist. One choice used with some success is the Tiao-Box likelihood ratio test. Bessler (*3*) provides a discussion of the test's properties and suggests its use in applied problems. (Lutkepohl (*10*) provides a comparative analysis of alternative lag selection procedures.)

Compared with more conventional, structural econometric analyses, VAR analysis is a new approach which gleans empirical regularities from time-ordered data. In doing so, it refrains from imposing *a priori* (theoretical) restrictions on data interrelationships. Rather, VAR models loosely utilize theory to suggest which variables constitute a dynamic system in equation 1. All variables in the system are initially considered endogenous, whereby each variable influences itself and all others in the system with lags. One purpose for fitting such models is to view the dynamic system with as few *a priori* restrictions as possible, allowing those regularities present in the data to reveal themselves. Bessler and Kling (*4*) provide a discussion of some of the properties and attributes of VAR econometric techniques.

Further, the VAR econometric technique addresses issues that are either ignored or inadequately treated by more conventional and theoretically based models (*2*, p. 111). These issues include lag lengths and measurements in the strength of relationships among economic variables. These issues also include the reaction times, durations, overall patterns, and statistical significance of responses of a system's modeled variables to a shock in one of the system's member variables.

Estimated VAR Model of Wheat Sector Price Transmissions

We demonstrate how a presumably drought-induced rise in farmgate wheat price influences the wheat sector's processor and consumer price levels. We chose a three-variable VAR of the farmgate wheat price (PF), processing price paid for wheat inputs (PP), and consumer prices of wheat-related goods (PC). Hereafter, these are referred to as the farmgate, processor, and consumer prices, respectively.

We formulate the following VAR model of a dynamic system comprised of PF, PP, and PC:

$$\begin{aligned} PF_t = {} & a_{fO} + a_{fT}*TRD + a_{f1}*PF_{t-1} + \ldots + a_{f12}*PF_{t-12} \\ & + a_{f13}*PP_{t-1} + \ldots + a_{f24}*PP_{t-12} \\ & + a_{f25}*PC_{t-1} + \ldots + a_{f36}*PC_{t-12} + f_t \end{aligned} \quad (4)$$

$$\begin{aligned} PP_t = {} & a_{pO} + a_{pT}*TRD + a_{p1}*PF_{t-1} + \ldots + a_{p12}*PF_{t-12} \\ & + a_{p13}*PP_{t-1} + \ldots + a_{p24}*PP_{t-12} \\ & + a_{p25}*PC_{t-1} + \ldots + a_{p36}*PC_{t-12} + p_t \end{aligned} \quad (5)$$

$$\begin{aligned} PC_t = {} & a_{cO} + a_{cT}*TRD + a_{c1}*PF_{t-1} + \ldots + a_{c12}*PF_{t-12} \\ & + a_{c13}*PP_{t-1} + \ldots + a_{c24}*PP_{t-12} \\ & + a_{c25}*PC_{t-1} + \ldots + a_{c36}*PC_{t-12} + c_t \end{aligned} \quad (6)$$

All a-coefficients are regression coefficients; the f, p, and c subscripts on the a-coefficients refer to the PF, PP, and PC variables, respectively. TRD is a time trend and captures influences associated with time. The a_{fO}, a_{cO}, and a_{pO} refer to the intercept terms on the PF, PC, and PP equations, respectively. The f_t, p_t, and c_t are the innovations for the PF, PP, and PC equations, respectively. All data are seasonally adjusted. All analyzed data are in natural logarithms because it is likely (*a priori*) that the three variables exhibit cointegratedness (*6*).

Monthly Bureau of Labor Statistics (BLS) data serve as PF, PP, and PC proxies. We estimate over the 1979:1-1986:12 period in order to exclude the effects of the 1988 drought. Farmgate wheat prices or PF are proxied by the producer price index (PPI) for wheat in the farm products group of indexes. The PPI for flour, in the processed foods and feeds index group, represents prices paid by processors of wheat-related inputs. Consumer-level prices for wheat-related goods are represented by the consumer price index, all urban consumers, flour and prepared mixes. Note that PC has, relative to PF and PP, a "diluted" wheat influence and is generally expected to respond to farmgate wheat price movements more sluggishly than processor prices (*13*).

All estimation and analysis was accomplished on Doan and Litterman's package, Regression Analysis of Time Series (RATS) (*5*). The Tiao-Box likelihood ratio test results (not reported here) suggest a 12-order lag (*8, 12*).

Influences of a Drought-Induced Farmgate Wheat Price Increase

The impulse response function simulates, over time, the effect of a once-only shock in one of the system's series on itself and on other series in the system. This is done by converting the VAR model into its moving average (MA) representation. The parameters of the MA representation are complex, nonlinear combinations of the AR regression coefficients. We chose to impose a one-standard-error shock in the farmgate wheat price on the system. This shock represents a 2.9-percent increase.

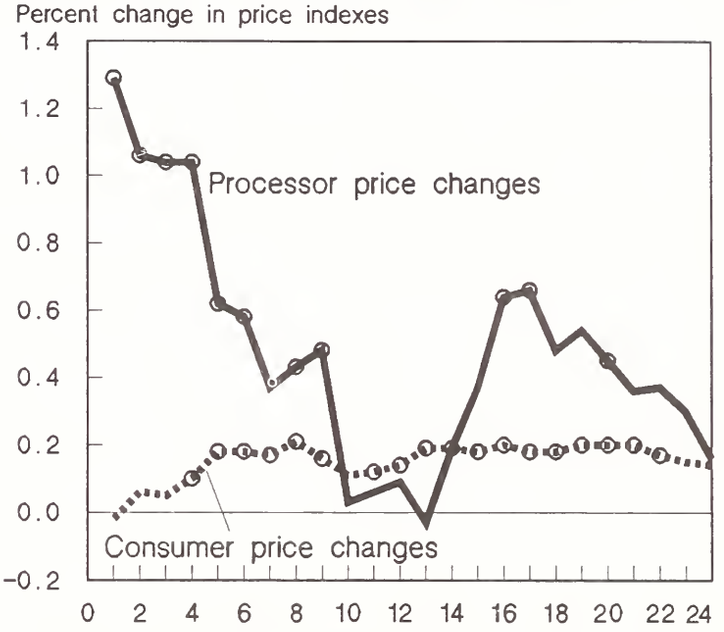
The PF, PP, and PC equations may have contemporaneously correlated innovations. Failure to correct for contemporaneously correlated current errors in the VAR relations will produce an impulse response function which is not representative of historical patterns. We implement a Choleski decomposition in order to orthogonalize the current innovation matrix, such that the variance/covariance matrix of the transformed current innovations is identity. The Choleski orthogonalization attempts to resolve the problem of contemporaneous feedback, which distorts impulse responses.

The Choleski decomposition requires a sometimes arbitrary imposition of a Wold causal ordering or chain among the current values of the dependent variables. We chose the ordering of PF to PP to PC for two reasons. First, intuition suggests that farm prices more directly affect processor prices than they affect consumer prices, and that processor prices more directly influence consumer prices than do farm prices (*1, 13*). Second, we simulate the effects of a farm price increase, presumably drought induced, on processor and consumer prices of wheat-related goods. The question investigated, therefore, suggests the ordering.

The farmgate price shock will now refer, in this article, to the presumably drought-induced rise in farmgate wheat price or PF. Months or steps will refer to the number of months following the farmgate price shock. (Step 1 is when the PF increase occurs.) All prices are those of wheat-related products.

Figure 1 presents the impulse responses of processor and consumer prices to a one-standard-error rise (2.9 percent) in farmgate price. The impulse responses are changes in the natural logarithms of the PF and PC indexes and approximate percentage changes in the nonlogged indexes. We used Kloek and Van Dijk's (*7*) Monte Carlo procedure to generate t-values for each impulse response in wheat-related processor and consumer prices. One uses an impulse's t-value to decide whether the impulse is statistically significant (here at the 10-percent significance level). That is, one rejects the null hypothesis that an impulse response is zero and concludes that there is adequate sample evidence to accept the alternative hypothesis—that the impulse response is nonzero—when the absolute t-value exceeds the critical value at the chosen confidence level. All of figure 1's statistically significant impulse responses are circled. Most processor price (PP) responses are significant for the first year and insignificant thereafter. The consumer price responses which are less pronounced than the PP responses, are mostly significant for the first 22 months.

Figure 1
Impulse responses in processor and consumer prices of wheat-based goods from a rise in farmgate wheat price[1]



1/ Circled impulses are significantly different from zero at the 10-percent level.

A number of results emerge from figure 1. Processor price immediately rises. These increases immediately peak at 1.3 percent, a change of less than half of the initiating 2.9-percent increase in farmgate wheat price. The processor price increases persist, but in a decelerating manner, for 12 months following the initiating PF increase before the impulses begin cycling downward through time in a path of diminishing strength. So, the processor price increases occur immediately following the farm price rise and may endure for approximately a year. Impulses in processor price take on statistical significance immediately, and most of these impulses are significant for the first year, after which most responses in processor price are not significant. We emphasize, therefore, only the first year of processor price responses.

A 3-month "reaction" time appears required for the farm-level shock in wheat price to be felt at the consumer level, because the consumer price impulses are not statistically significant until the fourth month. Rather than peaking immediately, consumer price increases, as expected, gradually strengthen. These increases peak in strength after about 8 months, and then extend out until almost the 2-year point, after which they become statistically insignificant. Unlike the processing stage of wheat-related goods, a stage which is closely tied to the annual wheat production cycle, consumption and hence consumer prices of wheat-related goods are not as annually oriented. Figure 1 shows how the farm price increase significantly affects consumer price beyond the 12 months during which processor price effects are significant. The consumer price rises are more gradually felt and more enduring than increases in processor price. At their 8-month peak of 0.21 percent, the consumer price increases are less than the 1.3-percent peak rise in processor price and less than 10 percent of the initiating rise in farmgate price.

The less pronounced, more gradual, but longer lasting nature of the wheat sector's consumer price impulses, relative to those of the processor price, may have a number of explanations. These explanations have been provided in a similar analysis of wheat-related prices (*1*) and are supported by this study's results (fig. 1). First, wheat-based products' storability at the consumer level may account for consumer price impulses having reached peak strength in a more gradual manner than processor price impulses. Wheat is storable, and consumer prices may take longer to respond fully because of the immediate inventory of wheat-related consumer goods made up of a previous and less costly crop. Time is required before the warehouse and retail shelf supplies of wheat-based goods made with the previous crop are consumed, insofar as the consumer price impulses require 3 months before achieving statistical significance (*1*).

Second, the farmgate wheat price is more removed from the consumer price than the processor price in the food and fiber chain, and this may also account for the impulses being more gradual and less pronounced at the consumer level than at the industrial level. Our results provide support for this explanation, insofar as the processor price impulses are larger than consumer price responses and take on statistical significance more immediately than consumer price impulses.

Third, the influences of a farmgate increase in wheat price may be more moderate at the consumer stage than at the processor stage because farmgate price comprises a lesser proportion, that is, it has a smaller influence on the consumer price than on the processor price. Processing and other additional services are added to wheat between the processor and consumer stages, and these nonwheat services may dilute the wheat price's influence on consumer price (*13*). (For example, there are the sweeteners, flavorings, and the packaging added to wheat-based food mixes.)

And fourth, the consumer price increases may last longer at a statistically significant level than processor price increases because consumption of wheat-based goods is not as closely tied to the annual nature of wheat production as industrial price. Consumption of wheat-based goods occurs throughout the year and may not be as closely tied to a 12-month production cycle as processor price. Consumer price impulses may therefore last with significance beyond the year or so that processor impulses last.

Decompositions of Forecast Error Variance

Analysis of decompositions of forecast error variance (FEV) is another tool of VAR econometrics for discerning the relationships among the modeled system's time series. FEV is, at alternative forecast horizons or steps, attributed to shocks in each of the dynamic system's series, such that a measurement of relative "strength" of relationships emerges. Error decompositions "attribute within-sample error variance to alternative series and thus give . . . a measure . . . useful in applied work." (*2*, p. 117) Decompositions of FEV are in table 1. We calculated FEV decompositions for 35 months or steps.

With a stationary series, the standard errors increase out into time but level off toward a value (*2*). Table 1 suggests that PF, PP, and PC are stationary.

A variable's exogeneity is suggested when its FEV is largely attributed to its own variation. Likewise, a variable's endogeneity is suggested when small proportions of its FEV are attributed to its own variation, and when large proportions of its FEV are attributed to the other time series in the system.

FEV decompositions suggest that farmgate wheat price is highly exogenous to the system. At the reported horizons, no less than about 58 percent of PF's FEV is self-attributed. Processor and consumer prices influence farm price FEV to a rather modest, but increasing, extent over time. By the 35th month, PF's FEV is 22.36 percent attributed to processor price innovation and 19.69 percent attributed to consumer price innovation.

Table 1—Proportions of forecast error variance, k months ahead, allocated to innovations in various price levels of wheat-based goods

Variable name	k	Standard error	Percentage explanation from PF	PP	PC
Farmgate price (PF)	1	0.0351	96.99	0.90	2.11
	6	.0463	87.72	8.50	3.78
	12	.0520	72.30	19.89	7.82
	18	.0596	68.67	16.76	14.57
	24	.0641	63.90	19.04	17.06
	34	.0702	57.98	22.42	19.61
	35	.0706	57.95	22.36	19.69
Processor price (PP)	1	.0193	76.26	23.07	.67
	6	.0285	71.92	26.96	1.12
	12	.0300	69.92	27.32	2.75
	18	.0337	69.00	22.56	8.44
	24	.0356	66.18	23.02	10.80
	34	.0387	59.12	26.35	14.52
	35	.0389	59.00	26.34	14.66
Consumer price (PC)	1	.0041	2.40	1.00	96.60
	6	.0072	21.41	29.83	48.76
	12	.0094	29.66	37.06	33.28
	18	.0107	41.50	31.98	26.52
	24	.0118	46.24	28.27	25.49
	34	.0134	42.05	28.84	29.11
	35	.0136	41.60	29.15	29.25

Processor price's FEV decompositions suggest a high degree of PP endogeneity. About 59-76 percent of processor price FEV is attributed to farmgate wheat price. Minor portions of PP's FEV are attributed to own-variation and to consumer price error.

Table 1 suggests a high level of endogeneity for consumer price. Less than a third of PC's FEV is self-attributed at horizons beyond 6 months. Farm price variation contributes most towards the explanation of the consumer price's FEV.

Findings and Conclusions

An increase in farmgate wheat price may be expected to immediately generate statistically significant increases in wheat sector processor prices, and these increases may last for about a year. Most of the industrial price rises are significant during this first year and insignificant thereafter. A 3-month reaction time appears required before wheat-related consumer price responds to wheat price increases at the farm level. The farmgate shock in wheat prices generates gradually strengthening consumer price increases that peak about 8 months after the farmgate shock. The consumer price increases last, with most being significant, for 22 months following the drought-induced farmgate price increase. The consumer price responses are more gradual, more tempered, but more enduring, than processor price impulses. Insignificant until the fourth month, the consumer price responses are mostly significant through month 22.

Farmgate wheat price is highly exogenous. Processor and consumer prices are highly endogenous, and their FEV's appear mostly explained by farm price of wheat.

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Applied Antle: A Better Method of Analyzing Welfare Effects of Pesticide Regulation

Pesticide Policy, Production Risk, and Producer Welfare: An Econometric Approach to Applied Welfare Economics. *By John M. Antle. Washington, DC: Resources for the Future, 1988, 100 pages, $12.95.*

Reviewed by Philip Szmedra

John Antle has been arguing since 1983 against the appropriateness of the conventional framework with which economists analyze agricultural producer behavior, the neoclassical theory of production. His arguments have merit. The neoclassical paradigm is both static and certain and does not provide much insight into the production problem when dynamics and risk enter the calculus as they do in agricultural production.

Farmers' pest management decisions in particular are characterized by two properties that make the process unique among production activities, and therefore do not allow the conventional theoretic approach much analytical worth. Pesticide input productivity depends on a random natural event, pest infestation, which makes productivity directly related to production risk. Secondly, inseason and interseasonal pest management decisions relate productivity directly to the dynamics of the production process. As social concern heightens for the harmful effects of some agricultural inputs, the regulations under which modern agriculture works will tighten.

Increased regulatory scrutiny of human and wildlife toxicity to pesticides and the environmental fate of many pesticide products demands accurate productivity measures to catalogue the benefits and risks of possible offending agents.

Here, then, is Antle's significant contribution to the current state of measuring the benefits that farmers derive from using pesticides and pest management programs. By developing an empirical framework in which producers' welfare under uncertainty can be analyzed with some confidence, policy guidelines for the regulation of suspected inputs can be made with *ex ante* knowledge of the welfare implications for different risk classes of producers. The methods developed by Antle allow quantitative investigation of the degree to which risk can bias conventional welfare analysis. This unique integration of production risk, sequential decisionmaking, and farmers' attitudes toward risk provides insight into the microeconomic effects of regulations restricting specific input use, indirectly promoting the use of alternative products or technologies. The central tenets of the book, the theoretical and methodological heart, reflect the author's progress to date in developing empirical methods to measure the technologies and behavioral attributes of a producer population under uncertainty.

The econometric procedure defined by the author requires data defining the outputs and inputs of a producer group and prices faced by them. Given the data, the methodology allows quantification of the technological relation between inputs and outputs as a conditional probability distribution of output given inputs. After estimating the technology, one can measure the distribution of producer risk attitudes. The virtuosity of the method is embodied in its ability to allow the evaluation of producers' economic efficiency and to analyze restrictive regulatory policies or innovative pest management techniques on the welfare and efficiency of producers.

After what is an essentially rigorous econometric exposition, Antle aims to soothe the reader's psyche by offering a case study of the California processing-tomato industry. He provides an interesting and thorough read, laying the groundwork for each integral piece of the previously set forth methodology. The case study findings reinforce this supposition: accounting for sequential decisionmaking by processing-tomato producers is central to obtaining reliable production technology information when production risk and time-related factors are important in producer decisionmaking. The implications are that laws restricting pesticide use have the greatest welfare effects on the most risk-averse individuals, who at the same time confront the greatest production risk. Restrictive laws that treat producers as a homogenous group are therefore an inefficient and inequitable method of restricting pesticide use.

Antle suggests that integrated pest management (IPM) programs, which ameliorate risk and therefore are a substitute for prophylactic pesticide applications, may offer a method to offset the welfare costs of restrictive pesticide laws to farmers most affected. This is where the author opens himself to minor criticism. Many farmers perceive IPM as a novel technology whose adoption carries with it inherent risk.

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IPM adoption rates are generally low, with only about 8 percent of U.S. cropland (27 million acres) enrolled in 30 State IPM programs supervised by the Cooperative Extension Service. USDA funding of IPM research projects, mostly field trials, was about $30 million in 1987. Relatively little Federal money is allocated to dissemination of information and producer education. Increased diligence in getting the word out about the potential of IPM toward improving the cost effectiveness of pest control practices or preventing environmental contamination through the overuse of pesticides would probably enhance producer perceptions of the IPM technology and increase the rate of adoption.

Lack of information about IPM would force individuals confronted with restrictive pesticide use regulations to search for an alternative chemical product rather than a risk-promoting alternative. Agricultural chemical manufacturers will oblige by developing new products for major crop uses that comply fully with tightened food safety and toxicity guidelines. Producers of what are considered minor crops may, in fact, be forced to implement nonchemical control methods, their demand for pesticides not sufficient to warrant chemical industry development of new minor use products.

If IPM is to become a significant welfare-equilibrating tool among producers facing restrictive pesticide regulations, institutional changes are required to make IPM a real alternative. But, this is a small argument about a small portion of this excellent book. Literature reviews at the end of every chapter provide a comprehensive catalogue of source material in IPM, modern welfare economics, stochastic production functions and their relation to econometrics, and risk-related topics. Though the author describes select chapters of his work as accessible to the general economist or informed lay person, the case study chapter cannot be read out of context. That is, one of the author's objectives is to empirically investigate the degree to which risk can bias conventional welfare analysis. One cannot impart much meaning to the empirical results without some understanding of the methods by which they were derived.

I recommend the book to applied resource and welfare economists. It is excellent as a supplementary text for a graduate level econometric or resource economics course. The book is a fitting culmination to this talented economist's early career work and an enjoyable read.

Macroeconomics and Agriculture: A Vast but Unfinished Research Effort

Macroeconomics, Agriculture, and Exchange Rates. Edited by Philip L. Paarlberg and Robert G. Chambers. Boulder, CO: Westview Press, 1988, 320 pages, $31.50.

Reviewed by Mark Denbaly

No other book on the effects of international macroeconomy on agriculture can be compared with this one. Because none exists. The book contains 10 independent essays presented at a conference sponsored by the International Agricultural Trade Research Consortium in 1986. The articles, therefore, are aimed at professional agricultural economists and graduate students with background in international finance and interests in the whole new field of macroeconomics and agriculture. Although 3 years have passed since the conference, the content still reflects what professionals know (or don't know).

The title suggests that exchange rates play a crucial role in all the essays. While this is true, it does not mean that other macroeconomic linkages are not explored. The crucial role that exchange rates play relates to the realization that the transmission mechanism between the international macroeconomy and agriculture is significantly different for fixed and flexible exchange rate systems. It is worth mentioning that non-exchange-rate linkage discussions are mostly general. Uses of a wide brush to paint the pictures, however, are in no way a weakness. On the contrary, the mostly general last five chapters by Just, Thompson, Schuh, Shane and Stallings, and Abbott are rich in insight and clearly identify many of the fruitful areas of research.

Having accepted the importance of exchange rates, Paarlberg and Chambers accordingly organize the essays. Part I, devoted to international finance, provides an excellent summary of recent theories of exchange rate determination and how the nature of the macroeconomic forces changed when the United States switched from a period of fixed to flexible exchange rate systems in 1973. Thompson, in chapter 7, points out that one reason for the lack of studies in the area of macroeconomic policy impact is that "far too few agricultural economists trained today have anything close to an adequate training in macroeconomics." In this sense, Part I becomes a prerequisite for the rest of the book. And, the rest of the essays prove the point.

Part II is committed to issues of macroagricultural linkages in the United States. Here, readers learn how the concepts and the frameworks developed in Part I could be used to examine theoretically and empirically and analyze descriptively a variety of influences that U.S. macroeconomic policy exerts upon agriculture. In Part III, these and other macroeconomic concepts are first used to analyze the macroagricultural issues seen from the point of view of the developing countries and, then, are used to provide an alternative approach to modeling macroeconomic linkages.

In chapter 2, Frankel and Froot analyze the evidence for the four hypotheses (monetarist, overshooting, safe haven, speculative bubble) that have been proposed to explain the large real appreciation of the dollar from 1981-85 and its subsequent depreciation. They argue that only the overshooting model is capable of explaining the rise and fall of the value of the dollar. Yet, even overshooting cannot fully explain the path taken by the dollar. Based on speculative bubbles, Frankel and Froot, therefore, propose an alternative exchange rate determination theory and show how it can work to explain the 1980-85 path of the dollar.

An agricultural economist without a strong background in international finance will find Frankel and Froot's essay difficult. That this article should be so difficult points up the degree of specialization that agricultural economists have to obtain. As Just stresses, deficiencies in current research still prevent information on the macroeconomic effects upon agriculture from reaching policymakers. To put it bluntly, without the knowledge base that is needed to understand Frankel-Froot type articles, we will be where Thompson says we are: having no adequate training and output.

The results of understanding the concepts that Frankel and Froot discuss are reflected in the article by Stamoulis and Rausser. They extend Dornbusch's overshooting exchange rate model to commodity prices. They show that money is nonneutral in the short run and that "the burden of adjustment to a monetary shock is borne by flexible price sectors [such as agriculture]."

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Overshooting has recently received much publicity, and Just stresses the importance of its policy implications for agriculture. Consequently, for policy reasons, demands have also been high for sound empirical estimation of the extent that agricultural prices overshoot. On the other hand, because of the assumptions (particularly the steady-state fixed-output assumption) that Dornbusch imposes, and Stamoulis and Rausser adopt, overshooting of spot prices is defined relative to the rate of change in the money stock. That is because under those assumptions, changes in money stock determine the changes in the equilibrium prices. However, as Mussa emphasizes (*Journal of Political Economy* in 1982) in defining overshooting, the reference point should be the equilibrium prices which must be specified as endogenous variables. Lest agricultural researchers mistakenly adopt Dornbusch's definition of overshooting in their empirical analyses, it should once again be stressed that the proper definition is, as in Mussa, the spread between the spot and the moving equilibrium prices.

Shei and Thompson also use their knowledge in international finance to carefully construct a macroeconomic linkage model for 1950-74. They use the model to compare the relative importance of the devaluation of the dollar, the decrease in world cereal production, the increase in Soviet grain purchases, and the increase in U.S. money supply in accounting for the sudden explosion of agricultural and general prices in 1973. The arguments that Shei and Thompson use to specify their macroeconomic linkages are consistent with McKinnon's description of how the U.S. economy functioned during the 1950's and 1960's when Bretton Woods (a fixed exchange rate system) prevailed. Not surprisingly, Shei and Thompson found that "the factor which accounted for the largest single share of the rapid 1973 agricultural and general price inflation in the U.S. was the 10 percent expansion in the domestic component of the monetary base in that year."

A point worth making, however, is that the money supply effect could have been even larger if Soviet behavior were endogenous—something that Abbott recommends. For example, the Soviet Union's purchase of grain could respond to movements in gold prices. In that case, the increase in the relative gold prices associated with the shortrun income effects of the money supply increase would push up the Soviet's demand for grain. In this sense, the estimated impact of the increase in Soviet grain purchases includes the effects of the 10-percent increase in money supply. Put differently, the simulated impact of the money supply increase on grain price is underestimated.

Discussions in international finance about the role that nontraded goods and real exchange rates play are relatively new. All essays, particularly Schuh's, use the concepts. For the majority of interested agricultural economists, however, the role of real exchange rates and nontraded goods still remains unclear. The topic deserved closer attention.

The arbitrage conditions that form the bases for the Frankel and Froot, and Stamoulis and Rausser essays were questioned by Abbott in his discussion about the advantages of structural approach to modeling macroeconomic linkages. He proposed formal empirical tests of arbitrage conditions in commodity markets. Work in this area has progressed since the conference in 1986. Results of a formal test on the validity of arbitrage conditions for grain markets, published in this journal in 1987, reinforce Abbott's point by strongly rejecting the strict form of the covered interest parity condition.

Paarlberg and Chamber's book does not exhaust all the effects that the international macroeconomy exerts on agriculture. The field of macroeconomic linkages to agriculture is relatively new. Much remains to be examined. The book eloquently demonstrates what agricultural economists interested in macroeconomic impacts on agriculture ought to do first: develop a solid base of knowledge in macroeconomics and international finance. It gives perfect examples of how theories about exchange rate determination can be used to successfully analyze the exchange rate-related issues in agriculture. In the process, the nature of several other macroeconomic linkages to agriculture are analyzed, identifying numerous important researchable topics. For this reason, I think the book will prove to be a valuable asset to professional agricultural research economists and graduate students.

The papers include: (1) "An Overview of Exchange Rates and Macroeconomics Effects on Agriculture" by Robert Chambers; (2) "Explaining the Demand for Dollars: International Rates of Return, and the Expectations of Chartists and Fundamentalists" by Jeffrey Frankel and Kenneth Froot; (3) "The U.S. Price Level and Dollar Exchange Rate" by Ronald McKinnon; (4) "Inflation and Agriculture: A Monetarist-Structuralist Synthesis" by Shun-Yi Shei and Robert Thompson; (5) "Overshooting of Agricultural Prices" by Kostas Stamoulis and Gordon Rausser; (6) "Exchange Rates and Macroeconomic Externalities in Agriculture" by Richard Just; (7) "U.S. Macroeconomic Policy and Agriculture" by Robert Thompson; (8) "Some Issues Associated with Exchange Rate Realignments in Developing Countries" by Edward Schuh; (9) "Financial Constraints to Trade and Growth: Crisis and Aftermath" by Mathew Shane and David Stallings; and (10) "Modeling Exchange Rate and Macroeconomic Linkages to Agriculture: Lessons from a Structuralist Approach" by Philip Abbott.

Externality Effects of Irrigation Development

Efficiency in Irrigation: The Conjunctive Use of Surface and Groundwater Resources. Edited by Gerald T. O'Mara. Washington, DC: A World Bank Symposium, The World Bank, March 1988, 196 pages, $19.95.

Reviewed by Rajinder S. Bajwa

In many developing countries, the creation or extension of irrigation agriculture has led to numerous deleterious side effects, commonly known as externality effects. Some of these effects, such as salt accumulations in the soils, depletion of aquifers, and disruption of natural drainage systems, are the focus of this book. The book grew from a 1983 World Bank conference in Washington, DC, that discussed the physical and economic effects that result when farmers rely on surface irrigation and certain common aquifer systems.

The papers in this book have developed important information on the nature of externalities associated with certain irrigation regions of the world. Irrigation experts will find the analyses especially useful as they become increasingly aware of the potential for conjunctive use of water.

O'Mara's introductory chapter suggests that innovative approaches, such as farmer participation in the planning and management of water resources through careful scheduling of water distribution, will reduce inefficiency in irrigation practices. Providing the heart of the book is the discussion of three regional models of irrigation development which resolve the effects of externalities in California (Coe), Pakistan's Indus Basin (Johnson), and the North China Plain (Ronghan and Lingen). In each case, the solution varies. In California, the overmining of ground water was resolved in part by importing surface supplies developed through the Feather River Canyon Project. In the Indus Basin, tube wells removed salt accumulation by lowering the ground-water tables. In the North China Plain, the conjunctive use of underground aquifer water to supplement the diversion of sediment-laden water from the Yellow River was the top priority. These papers show sound empirical analyses based on extensive fieldwork.

On other issues, Randall argues for the replacement of such well-known concepts as "common property resources," "public good," "natural monopoly," and "externalities" by alternative concepts as nonexclusiveness and nonrivalry. Randall says the new terms are more useful than the old ones, which do not define the sources of market failures properly because they are interpreted in a variety of ways by different people. The reasoning and conclusions are somewhat abstract and would be difficult to apply in practice.

Radosevich illustrates the role of water laws including policies and institutions that have evolved in various regions of the world to guide water development. The discussion is incisive and will prove influential in the long run for developing water resources through innovative legal institutions. Radosevich claims that "the law may be inappropriate to the present problems or may not provide the proper guidance." He cites water pricing as an example where the present laws fail to provide an efficient use of water resources. He contends that laws should permit water-user fees to be charged by volume to encourage more efficient use of water.

The last part of the book revolves around the main analytical methods applied to analyze water resource management models. Gorelick reviews ground-water management models for efficient allocation of groundwater resources. However, lack of physical measurements on aquifer processes makes these models less practical in analyses. Rogers, Harrington, and Fiering also discuss new approaches to using mathematical programming for resource allocation. The authors attempt to link a sequence of linear programming formulations, each representing a different stage of development in an integrated system, resulting in enormously large matrices of the constraining set, which lead to needless computational difficulties.

In another discussion of the Indus Basin, O'Mara and Duloy divide the area into agroclimatic zones to identify the differences in soils and climate as they are reflected in the region's cropping patterns. The entire Indus Basin is partitioned into 53 irrigated regions known as polygons. Each polygon is essentially homogeneous with respect to ground water and preserves boundaries that are significant to ground-water aquifer systems. Each polygon also receives surface water on a monthly basis from the control points of the surface water delivery system. Thus, interdepend-

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ence is built into the water development measures of the Indus Basin system. O'Mara and Duloy convincingly establish that externalities are really the crux of water resource management and that progress in internalizing these externalities is an urgent challenge for development.

Zapata develops a model using the existing institutional arrangements for water allocation (except for the optimal pumping tax) in the case of ground-water uses in western Argentina. This model, however, neglects dynamic optimization issues such as the optimum level of storage in the aquifer, and ignores other environmental effects, such as the mixing of fresh water with saline ground water.

In contrast to Zapata's analysis, Bredehoeft and Young address the efficient conjunctive use of water from ground and surface sources along a reach of the South Platte River in Colorado. The authors skillfully display technical ingenuity in simulating the physical interdependence among different water supply sources in a relatively dry environment where the surface water supply is limited. As more wells are installed, the variation in farm net income tends to be reduced, and the net income increases.

Thomas evaluates policy choices for two arid countries, Qatar and Libya. The recent tapping of new petroleum reserves in both countries has opened up some innovative options for water development (including the use of cheap petroleum energy in desalting sea water for agricultural purposes) which were not previously available. Thomas points out that, in the long run, the development of ground water in desert aquifers will be costly to maintain because of falling water tables and rising energy costs. The goal of achieving self-sufficiency in food production, though politically attractive as long as oil supplies and revenues are available, may not be economically feasible in the long run.

Basu and Ljung describe a ground-water scheduling sequence strategy in India to maximize crop yields by minimizing plant stress conditions at crucial stages of crop growth. The authors discuss yields from additional ground-water use for wheat, mustard, and castor. They treat externalities as inefficiencies in irrigated agricultural systems prevalent in many parts of India, seeing possible compensation for inefficiencies arising from seepage losses by means of extracting the "lost" water and using it for productive purposes. The authors do mention that the pumping of ground water should be limited to the recoverable recharge, but fail to specify the size of recoverable recharge and the duration of the possible recharge period. The strength of this paper lies in developing an appropriate irrigation schedule for conjunctive use that is primarily based on a water demand schedule.

In my view, these papers are worth reading, and O'Mara should be commended for providing us these analyses in a book form where one could use this information as an aid in understanding various aspects of irrigation development.

The papers include: (1) "The Efficient Use of Surface Water and Groundwater in Irrigation: An Overview of the Issues" by Gerald T. O'Mara.

Part I: ***Theoretical Issues,*** (2) "Market Failure and the Efficiency of Irrigated Agriculture" by Alan Randall; (3) "Legal Considerations for Coping with Externalities in Irrigated Agriculture" by George Radosevich.

Part II: ***Case Studies of Conjunctive Use,*** (4) "Responses to Some of the Adverse External Effects of Groundwater Withdrawals in California" by Jack J. Coe; (5) "Large-Scale Irrigation and Drainage Schemes in Pakistan" by Sam H. Johnson III; (6) "Development of Groundwater for Agriculture in the Lower Yellow River Alluvial Basin" by Huang Ronghan.

Part III: ***Analytical Methods and Applications,*** (7) "A Review of Groundwater Management Models" by Steven M. Gorelick; (8) "New Approaches to Using Mathematical Programming for Resource Allocation" by Peter P. Rogers, Joseph J. Harrington, and Myron B. Fiering; (9) "Modeling Efficient Conjunctive Use of Water in the Indus Basin" by Gerald T. O'Mara and John H. Duloy; (10) "Estimating the Externalities of Groundwater Use in Western Argentina" by Juan Antonio Zapata; (11) "Risk Aversion in Conjunctive Water Use" by John D. Bredehoeft and Robert A. Young; (12) "Groundwater as a Constraint to Irrigation" by Robert G. Thomas; (13) "Irrigation Management and Scheduling: Study on an Irrigation System in India" by D.N. Basu and Per Ljung.

Lifting the Siege on Japanese Agriculture

Japanese Agriculture Under Siege: The Political Economy of Agricultural Policies. *By Yujiro Hayami. New York: St. Martin's Press, 1988, 145 pages, $45.*

Reviewed by William T. Coyle

Japanese policymakers must have read earlier drafts of this book by Hayami. Recent agricultural and trade policy changes undertaken by Japan seem to closely follow his prescription for "lifting the siege" on Japanese agriculture by raising productivity in Japanese agriculture so that it can be viable without trade barriers. Fitting into Hayami's framework are the elimination of import quotas (p. 118) as was agreed to in the GATT-12 case in early 1988 and the beef and citrus agreement in July 1988, significant cuts in rice prices (p. 116) in 1987 and 1988 (the first in 30 years), and the recommendation of using "market mechanisms" (pp. 119-121) to achieve structural improvements in the farm sector in the 1986 and 1987 Maekawa reports.

Even his view that true food security for Japan lies not in self-sufficiency but in international cooperation (pp. 122-123) is consistent with Japan's emerging role as the world's leading foreign aid donor and its more activist role in providing leadership and contributing ideas to solving the Third World debt problem. The latter was manifest at the Economic Summit in Toronto last year.

Japan's recent actions and Hayami's vision cast a more optimistic light on the potential for reform in Japanese agriculture. In many ways, Japan's efforts to reform its agriculture since the beginning of the Uruguay round of multilateral trade negotiations (Sept. 1986) are the most dramatic in the developed world. For many years, Japanese agricultural and trade policy changes were slow and peripheral to the farm sector, rice market liberalization was a taboo subject, and the farm lobby's political clout seemed insurmountable. There was a sense that things would get more distorted as time went on, that there was something deterministic about economic development and ever higher levels of farm protection and assistance in Japan.

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According to Anderson and Hayami's earlier book, *The Political Economy of Agricultural Protection* (Sydney: Allen and Unwin, 1986) (p. 114): "The clearest lesson...is that agricultural protection is unlikely to disappear. On the contrary, it will probably continue to increase in East Asia and other protected economies and spread to less developed economies as they industralize (or otherwise lose their comparative advantage in agriculture...). The commonly held view that the political influence of the farm sector will diminish as the number of farmers declines is clearly erroneous, at least until some threshold is reached. This is most obvious in Japan, where the nature of the demographic change that has accompanied industrialization, and of the agricultural cooperative organization that has entrenched itself in rural area, ensure that the demand for agricultural protection will continue to expand."

At the time the Anderson and Hayami book was published in 1986, government assistance in Japanese agriculture had been increasing during the 1980's. Since about 80 percent of assistance to Japanese agriculture comes from high producer prices maintained by restrictive border measures and paid for by consumers, low world prices and an appreciating yen, particularly after 1985, raised farm support even though budgetary programs were being cut during 1981-87. But, with cuts in rice supports in 1987 and 1988 and significant reform in the beef and citrus sectors underway, Japanese Government support to farmers may have finally begun to decline. Whether this trend continues depends, of course, as much on exchange rates and world commodity prices as on a continuing national commitment to reform.

Hayami's essential point in *Japanese Agriculture Under Siege* is that Japanese agriculture does not have to be forever inefficient and the lightning rod for foreign criticism, that it can be viable without border restrictions, but that many changes have to be made. His reform scenario centers on the increased use of market principles and the activation of a land rental market. By reducing support prices for major farm activities and deregulating the land rental market, he envisions a greater willingness on the part of part-time farmers to rent out most of their land to full-time progressive farmers, perhaps retaining a small garden plot. Full-time farmers would then have the opportunity to put together units of about 10 hectares (the average for West Germany), take advantage of

economies of scale, and reduce their costs. Efficiencies gained through structural reform would make Japan's farm sector more internationally competitive and more able to cope with trade liberalization measures. Structural reform and trade liberalization measures would be complementary, with the latter satisfying the repeated access demands of foreign food suppliers and putting cost-cutting pressure on Japanese farmers.

The nature of Japan's agriculture would change. It would be smaller as a percentage of GNP, dominated by full-time producers, and switch from traditional rice to livestock-centered farming. The rest of the economy would become even more efficient than it already is, something for the U.S. auto industry and other industries to think about.

Hayami's thesis is intriguing and far more plausible now than when I heard it for the first time 12 years ago. To be safe, an observer of Japanese agriculture and farm policy should maintain a healthy skepticism. While the forces for change seem to be mounting, including the rapid aging of the farm population, the most important characteristic of post-World War II Japanese agricultural policy has been the slowness of change. Average farm size grew from about 1 hectare in 1960 to only 1.2 in 1985, so that the fragmented nature of rural landholdings remains a major impediment to reaching Hayami's goal of larger, more competitive farms. Furthermore, the resistance to reform by what Hayami calls the "iron triangle"—the Ministry of Agriculture, Forestry, and Fisheries; the Liberal Democratic Party (LDP); and the farm cooperative (Nokyo)—cannot be underestimated. The recent Recruit scandal and weakening LDP support in rural areas triggered by the beef and citrus agreement are also likely to stall agricultural reform in the short term.

In addition to his framework for policy reform, Hayami provides excellent background chapters on the historical development of Japanese agriculture and a profile of the types and extent of government assistance in the farm sector. This is must reading for the student of east Asian agriculture.

Empirically Valuing the Security of Land Tenure

Land Policies and Farm Productivity in Thailand. By Gershon Feder, Tongroj Onchan, Yongyuth Chalamwong, and Chira Hongladarom. Baltimore: Johns Hopkins University Press for the World Bank, 1988, 165 pages, $18.95.

Reviewed by William F. Hyde

Land tenure has reappeared in recent years as a substantial research and policy topic in agriculture and resource economics. One can make the case that secure tenure is the key to rural development and resource management, particularly for many developing countries in Latin America, Africa, and Asia. Yet, the focus of most research published to date is on the varying institutional possibilities (the wide range of rules, rights, and regulations) that describe tenure in specific situations. The literature is generally either conceptual or anecdotal. Feder and his coauthors take the inquiry into land tenure a long step forward. Theirs is the first theoretically solid and analytically complete empirical case study. It assesses the impacts of secure land tenure on farm productivity in interior Thailand. This review provides more of a synopsis of their book than is common in most reviews because of both the importance of the book and the quality of the analysis.

The basic analysis relies primarily on survey data from three villages, each with more than 360 farm household observations. Agricultural land in each of these villages falls into two extreme tenure categories, one resembling fee simple ownership and one composed of squatter plots on public land. The existence of only two well-defined categories greatly simplifies the analysis. Therefore, the authors go to considerable length to explain the tenurial detail of this Thai case. They contrast a range of borrowing and lending experiences, farm plot distribution, community infrastructure, the record of land exchange, farmers' experience with eviction, and farmers' expectations of the benefits of titling, all in order to formally characterize the local situation and to justify reliance on only two tenurial categories in their subsequent analysis.

Later, the authors examine data from a fourth village with these two tenure categories plus one more category, STK (the Thai abbreviation for temporary cultivation rights). STK certificates provide usufruct rights to squatters but prohibit land transactions.

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Observations from the first three villages furnish insight into the impacts of tenure security on credit, input use, output productivity, land value, and income. These insights eventually permit the authors to draw conclusions regarding both the private and social net benefits of secure title. Observations from the fourth village permit similar conclusions regarding STK.

The modeling effort itself is a contribution to research in land tenure, not for its originality or its theoretical breakthrough, but for its clarity and its thoroughness. This book is much more than a statistical estimation of the relationship between secure title and land value. The authors' figure 1 summarizes by linking 1) titling to security and to increases in both the supply and demand for credit, and showing how 2) increased credit permits increased investment in fixed productive inputs, which 3) creates the demand that, together with the expanded supply of credit, stimulates increases in variable inputs. Increases in both fixed and variable inputs then 4) expand productivity per acre and increase 5a) incomes and 5b) land values. These conceptual links are theoretically sound and consistent with hypotheses proposed in the previous literature on tenure. They go well beyond the statistical correlations that tend to be the analytical extent of most previous empirical literature.

The bulk of the book develops these conceptual links in theoretical detail and proceeds with the six basic econometric investigations. The theory starts with a risk-averse farmer who maximizes wealth over his lifetime while adjusting for the expectation of eviction from insecure landholdings. The result is a series of 13 tightly reasoned propositions that are tested subsequently in the empirical analysis. The empirical tests include various alternative functional formulations, for example: a) both equilibrium and disequilibrium tests of the institutional credit market and b) examinations of fixed investment measured independently as land, two kinds of capital formation, and changes in the capital-land ratio. The measure of land is always adjusted for quality.

The resulting regressions are replicated independently for each of the three villages. The econometric results are statistically reliable and remarkably consistent both with theory and across villages. One village provides the unusual case where title produces small, sometimes insignificant impacts. The apparent anomaly is explained by the large amount of noninstitutional credit available in this village and the use of collateral other than titled land to secure noninstitutional loans.

The Thai Government has begun a program of issuing nontransferable usufruct rights (STK's) to squatters. Feder and his co-authors examine one village (over 300 observations) where this program is active. They anticipate that the lack of transferability of these rights restricts the use of STK permits as collateral with lending institutions and, therefore, restricts their economic benefit. The econometric analysis supports their anticipations. STK permits fail to enhance land value (or capital accumulation or land improvement). Land with STK permits is comparable in value to land with no title and is substantially less in value than land with secure title. This value difference is also statistically significant.

The authors conclude that titling results in 25- to 130-percent increases in land value. The social net benefits of titling (adjusted for subsidized administrative costs and differences between private and social risk aversion) exceed 25 percent in all villages except the one with a substantial amount of noninstitutional credit.

The authors' caveats on these findings stress credit availability and environmental impacts. The market for rural credit is heavily administered. Alternative administrative practices would adjust the authors' conclusions, although they feel their general conclusions regarding the importance of secure tenure would be robust even in an undistorted institutional credit market.

I disagree with the authors on only one issue. They suspect that titling is associated with negative environmental impacts. Secure tenure, it seems to me, provides greater incentive to protect the land's long-run productivity. The authors' capital formation regressions support this conclusion, developed country observations on soil erosion and soil protection support it, and my own observations of developing country forestry support it. Poor environmental management of forests and rangelands tends to occur where there is no enforceable claim on the land. Specifically, this has been my observation in the uplands of Thailand, and it is my reason for anticipating even greater social benefits than the authors claim for secure tenure and for titling programs.

My conclusion is that this book is a carefully organized, tightly reasoned effort. The mathematics is easy to follow; the economics is sound and complete. The analysis has important implications for the value of secure tenure and titling programs everywhere, not just in Thailand or on agricultural land. The analysis of Feder and his co-authors has strong policy implications for the likely failure of partial tenure solutions like STK on public lands throughout the developing world. If broadly read, this book has strong policy implications even for nonagricultural resource problems like tropical deforestation.

This book should be a model for many more empirical analyses of the gains from secure tenure. It is one of the more exciting books I have read in a while. It can become a classic in the field.

After this review was written, *Land Policies and Farm Productivity in Thailand* was selected as 1989 winner of the American Agricultural Economic Association award for "quality of research discovery."

Most Food Program Subsidies Promote Food Security over Nutritional Improvement

Food Subsidies in Developing Countries: Costs, Benefits, and Policy Options. Edited by Per Pinstrup-Andersen. Baltimore: The Johns Hopkins University Press, 1988, 374 pages, $39.50.

Reviewed by Mervin J. Yetley

While the adequacy of food consumption in developing countries is of considerable interest to citizens in industrial countries, neither this topic nor related issues have received commensurate study by university scholars. As a result, much of the research leadership on food demand and its issues has been provided by international research centers, especially the International Food Policy Research Institute (IFPRI).

Per Pinstrup-Andersen has assembled and edited a set of papers based on research done primarily at IFPRI. The papers cover a wide range of issues associated with food subsidies, such as implications for food consumption, and implicit and explicit costs to economies. Pinstrup-Andersen has done an excellent job of cross-referencing related material throughout the book, so the reader can begin with any chapter with assurance of being referred to detailed discussions. Pinstrup-Andersen also provides an excellent summary, Part I, which serves as the introduction to Part II.

The nine chapters in Part II synthesize findings on a wide range of issues related to food subsidies. This section contains some interesting results and provides the basis for understanding the policy controversy that frequently accompanies the design and implementation of food subsidy programs. Some readers will be surprised to find that food security, rather than nutritional improvement, is the main objective of most food subsidy programs. The pre-eminence of a non-nutritional goal leads to the possibility of the subsidy yielding a net decrease in caloric consumption, depending upon the cross-commodity substitution effects induced by the subsidy.

Policy controversies should come as no surprise given the multiple, and sometimes conflicting, goals assigned to food subsidy programs. However, Pinstrup-Andersen and the authors do not recommend one policy over another but rather discuss results of studies of food assistance programs. Thus, the chapters of Part II assess issues of effectiveness and efficiency of programs such as in-kind commodity distribution, price subsidies on selected food commodities, cash or wage supplements, and rationing. Other issues covered include implicit and explicit program costs, implications of macroeconomic policies for program results, program implementation considerations, and alternatives to food subsidy programs, including direct income augmentation. Political considerations are also discussed. Development specialists and decision-makers in developing countries looking for simple answers will not find them in this book. The authors repeatedly state that the final net effect depends upon a host of interrelated factors. What readers will find is an excellent discussion of these interrelated factors and unanticipated consequences that may accompany certain programs.

One of the critical, interrelated factors frequently overlooked is the quantity and quality of administrative talent needed to properly implement a food intervention program. Another frequently omitted issue is the impact of macroeconomic policies on the need for and effectiveness of food subsidies, and the effect of food subsidies on the effectiveness of macroeconomic policies. The depth and scope of the discussion of these less familiar issues and the interrelating of the important factors is one of the book's major contributions.

Part III contains a series of case studies illustrating the issues and results discussed in Part II. Readers with a particular interest in Egypt, the Philippines, Bangladesh, India, Pakistan, Sri Lanka, Brazil, Mexico, or Zambia will find this part of the book especially useful.

Part IV attempts to generalize implications for macro- and micro-policy. These concluding chapters are particularly important for readers interested in either developing countries not covered in the analytical studies which underlie the material in Part II, or the country case studies of Part III.

Not all readers interested in developing countries will find this book immediately useful. Readers looking for insight into implications of the current General Agreement on Tariffs and Trade (GATT) negotiations for the economies of developing countries

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and the potential for international trade will find only scattered information. Economists interested specifically in food demand parameters will find the referenced material that underlies these papers to be more helpful than the book itself, especially if the recently published *Food Demand Analysis: Problems, Issues, and Empirical Evidence,* edited by R. Raunikar and Chung-Liang Huang (Ames: Iowa State University Press, 1987) is added to the reference list. Researchers interested in the comparison of food demand parameters cross-nationally will find material published by USDA's Economic Research Service a useful addition. However, these qualifications do not diminish the fact that this book is well written and is one of the most complete discussions of the impacts and implications of food subsidies available. It will be a very helpful reference for economic development professionals in developing countries.

The papers include:

Part I: Introduction (1) "The Social and Economic Effects of Consumer-Oriented Food Subsidies: A Summary of Current Evidence" by Per Pinstrup-Andersen.

Part II: Syntheses of Findings (2) "The Effectiveness of Consumer-Oriented Food Subsidies in Reaching Rationing and Income Transfer Goals" by Per Pinstrup-Andersen and Harold Alderman; (3) "Food Consumption and Nutritional Effects of Consumer-Oriented Food Subsidies" by Shubh K. Kumar and Harold Alderman; (4) "Macroeconomic and Trade Implications of Consumer-Oriented Food Subsidies" by Grant M. Scobie; (5) "Explicit versus Implicit Food Subsidies: Distribution of Costs" by Alberto Valdes; (6) "Implications of Consumer-Oriented Food Subsidies for Domestic Agriculture" by Joachim Von Braun; (7) "Political Calculations in Subsidizing Food" by Raymond F. Hopkins; (8) "Design and Implementation Considerations for Consumer-Oriented Food Subsidies" by Beatrice Lorbe Rogers; (9) "Alternatives to Consumer-Oriented Food Subsidies for Achieving Nutritional Objectives" by Eileen T. Kennedy; (10) "Income-Augmenting Interventions and Food Self-Sufficiency for Enhancing Food Consumption among the Poor" by Shlomo Reutlinger.

Part III: Results from Country Studies (11) "Food Subsidies in Egypt: Benefit Distribution and Nutritional Effects" by Harold Alderman; (12) "Food Subsidies in Egypt: Implications for the Agricultural Sector" by Joachim Von Braun; (13) "Food Subsidies in Egypt: Macroeconomic and Trade Implications" by Grant M. Scobie; (14) "Food Subsidies in the Philippines: Preliminary Results" Marito Garcia; (15) "Structure, Costs, and Benefits of Food Subsidies in Bangladesh" by Raisuddin Ahmed; (16) "Costs and Benefits of Food Subsidies in India" by P.S. George; (17) "Pakistan's Ration System: Distribution of Costs and Benefits" by Beatrice Lorge Rogers; (18) "Food Subsidy Changes in Sri Lanka: The Short-Run Effect on the Poor" by Neville Edirisinghe; (19) "Effects of Brazilian Wheat Subsidies on Income Distribution and Trade" by Geraldo M. Calegar and G. Edward Schuh; (20) "Fiscal Cost and Welfare Effects of the Maize Subsidy in Mexico" by Nora Lustig; (21) "Design, Income Distribution, and Consumption Effects of Maize Pricing Policies in Zambia" by Shubh K. Kumar; (22) "Distributional Consequences of Alternative Food Policies in India" by Hans P. Binswanger and Jaime B. Quizon.

Part IV: Implications for Food Policy: Generalizing Beyond Study Countries (23) "Some Macroeconomic Policy Implications of Consumer-Oriented Food Subsidies" by Ammar Siamwalla; (24) "Some Microeconomic Policy Implications of Consumer-Oriented Food Subsidies" by Per Pinstrup-Andersen.

National Policies and Agricultural Trade. *Organization for Economic Cooperation and Development. Paris, 1987, 344 pages, $25.*

Reviewed by Mathew Shane

There are serious conflicts in global agricultural markets between growing world interdependence and domestically focused agricultural policies. The current Uruguay round of multilateral negotiations under the auspices of the General Agreement on Tariffs and Trade (GATT) offers a strategic opportunity to alter fundamentally international agricultural markets and to overcome growing conflicts. Domestically focused policies have led to a misalignment of production and use of agricultural products with resulting cycles of substantial surpluses followed by global agricultural shortages.

In this book, the Organization for Economic Cooperation and Development has provided a benchmark study on the magnitude and consequences of national agricultural policies. As such, it is a major contribution to the global analysis of the effects of government interventions in agriculture. It should be read by all serious students of the subject. The report is timely and relevant given the current multilateral GATT negotiations.

The report is divided into six chapters. Eight annexes follow. In some ways, these are the most interesting part of the report. For instance, tables 2 and 3 on pages 117-8 provide detailed estimates of producer subsidy equivalents (PSE's) and consumer subsidy equivalents (CSE's) by country and commodity. Table 4 on page 134 provides estimates of the level of costs of agricultural policies compared with gross domestic product (GDP), gross value added by agriculture at market prices (GVA), and final value of agricultural production (FVAP). Agricultural subsidies are, not surprisingly, small compared with GDP since agriculture in industrial market economies is a relatively small sector. The costs of the policies in terms of GVA and FVAP, however, are enormous ranging from a low of 6.1 percent of FVAP in Australia to a high of 58 percent in Japan. Compared with GVA, the high exceeds 100 percent for Japan and approaches 100 percent for the EC.

The conclusions of the study are equally unsurprising, supporting the same general conclusions which have been flowing out of the work at ERS and elsewhere. Nonetheless, the importance of these conclusions make them worth scrutinizing:

- "Policies...have...aggravated the growing imbalance between supply and effective demand at current prices and the spread of the imbalance to most commodities and to most countries." (p. 7)
- "The level of assistance to agriculture during the period 1979-81 was quite substantial averaging over one third of the value of output for OECD producers and over 60 percent, on average, for dairy and rice. About half of this assistance came from Government budgets and half from transfers from consumers. Support levels were this high even though this period was one of generally buoyant markets with limited intervention compared with more recent years." (p. 13)
- "Agricultural trade problems have their origin in a set of domestic policies that shield producers from world market signals and are incompatible with the upward trend in agricultural productivity and the low growth in food demand facing OECD countries. Policies, whose principal although not exclusive purpose is to improve the level and stability of the standard of living of farmers, have been largely implemented on the basis of raising the value of output resulting in the expansion of supply beyond market requirements." (p. 24)
- The income objective of agricultural policies "has not been entirely achieved: to achieve it in a more economic and more socially-acceptable way and with the minimum distortion to trade requires a switch away from measures that stimulated output." (p. 25)
- "Policies...have evolved to counteract the effect of other policies, either of domestic origin or not. A partial approach, even a unilateral approach, could bring benefits to domestic consumers, to other economic sectors through better resource use and to other exporters if reductions are made by those countries which heavily subsidise exports. However, the partial approach is likely to generate some further imbalances in some cases, exacerbating international trade tensions, and to yield significantly lower benefits than multilateral reform. If progress is to be made in resolving the serious problems confronting all OECD members, a multilateral, multi-commodity approach, both to the analysis and the resolution of the problems, should be urgently pursued." (p. 49)

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- "The higher the degree of insulation of domestic markets, the larger are the world price changes which result from unforeseen changes in market circumstances... The inflexibility of agricultural policies has led in most cases to agricultural trade actions by OECD countries that have exported agricultural adjustment pressures to world markets." (p. 60)

- "There is little choice but to accept that, for the OECD area, adjustment at the point of production is an essential part of reform. Such a reorientation, by reducing the export of adjustment pressures will be a major contribution to an enduring improvement in the situation." (p. 61)

- "The present problems of agriculture stem primarily from past policy incentives which have led to an excessive expansion of production capacity while the food needed could be produced with far fewer resources and at a lower cost with consequent gains to the whole economy. Furthermore agricultural assistance policies have not been sufficiently adjusted to take account of productivity increases and the rigidity of the support mechanisms have [sic] not only prevented the appropriate market signals from being transmitted to producers, but has in several cases been interpreted by farmers as an encouragement to produce." (p. 69)

Although the study is well done and an important contribution to this area, there are some serious limitations to the analysis. For example:

- The study has limited commodity and country coverage. The focus is on liberalization of the major industrial market economies' agriculture. Although the developing economies tend not to subsidize their agriculture, they still intervene substantially in their agricultural sectors. Any analysis that assumes that the developing countries are not subject to policy reform is omitting a major part of the global agricultural economy which could lead to serious errors of interpretation.

- A partial equilibrium global commodity model is used. No consideration is given of the interindustry effects of liberalization of agriculture. Other analyses of multilateral liberalization using general equilibrium models conclude that major changes occur in the nonagricultural sectors because of trade liberalization.

- The analysis is static in nature. Most of the benefits of trade liberalization will come from the induced structural changes which occur because of the removal of constraints to economic agents. As such the benefits as estimated in this study should greatly understate the potential benefits of policy reforms.

- The liberalization scenario is a very limited one. One must ask whether a 10-percent reduction in subsidies represents policy reform at all. An analysis conducted at ERS suggests that almost all countries could undertake such a reduction without a major change in their policy regimes. The increase in world prices caused by the 1988 U.S. drought reduced subsidy levels as measured by PSE's by more than 10 percent.

- Finally, what is the United States hoping to accomplish by the multilateral negotiations under the GATT? Reducing subsidy levels? Reducing the trade-distorting effects of the current policies? If the United States is interested in the latter, then the PSE's are a poor measure of trade-distorting policies. Rethinking of the analysis, and better tools for the measurement of government subsidies are required.

The United States faces a world that is increasingly interdependent, both in terms of trade and financial resources, and yet agricultural policies are still designed for a world in which international consequences of domestically focused policies are quite small. The increasing divergence between this growing interdependence and interventionist agricultural policies is the longrun driving force toward reform.

Aside from the obvious benefits of trade liberalization and as clearly recognized as the current inefficiencies within existing policies, the movement toward reform has been slow, unsteady, and uncertain. The current lack of progress in the GATT negotiations on agriculture is an indication of how difficult it is to change policies that benefit a few well-organized groups whose costs are broadly dispersed.

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